NONRESIDENT TRAINING COURSE

September 2000

Operations Specialist, Volume 1

NAVEDTRA 14308

Although the words "he," "him," and "his" are used sparingly in this course to enhance communication, they are not intended to be gender driven or to affront or discriminate against anyone.

PREFACE

By enrolling in this self-study course, you have demonstrated a desire to improve yourself and the Navy. Remember, however, this self-study course is only one part of the total Navy training program. Practical experience, schools, selected reading, and your desire to succeed are also necessary to successfully round out a fully meaningful training program.

THE COURSE: This self-study course is organized into subject matter areas, each containing learning objectives to help you determine what you should learn along with text and illustrations to help you understand the information. The subject matter reflects day-to-day requirements and experiences of personnel in the rating or skill area. It also reflects guidance provided by Enlisted Community Managers (ECMs) and other senior personnel, technical references, instructions, etc., and either the occupational or naval standards, which are listed in the *Manual of Navy Enlisted Manpower Personnel Classifications and Occupational Standards*, NAVPERS 18068.

THE QUESTIONS: The questions that appear in this course are designed to help you understand the material in the text.

VALUE: In completing this course, you will improve your military and professional knowledge. Importantly, it can also help you study for the Navy-wide advancement in rate examination. If you are studying and discover a reference in the text to another publication for further information, look it up.

2000 Edition Prepared by
OSCS(SW) Michael Murphy

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Sailor’s Creed

“I am a United States Sailor.

I will support and defend the Constitution of the United States of America and I will obey the orders of those appointed over me.

I represent the fighting spirit of the Navy and those who have gone before me to defend freedom and democracy around the world.

I proudly serve my country’s Navy combat team with honor, courage and commitment.

I am committed to excellence and the fair treatment of all.”

TABLE OF CONTENTS

Course Assignments follow index.

INSTRUCTIONS FOR TAKING THE COURSE

ASSIGNMENTS

The text pages that you are to study are listed at the beginning of each assignment. Study these pages carefully before attempting to answer the questions. Pay close attention to tables and illustrations and read the learning objectives. The learning objectives state what you should be able to do after studying the material. Answering the questions correctly helps you accomplish the objectives.

SELECTING YOUR ANSWERS

Read each question carefully, then select the BEST answer. You may refer freely to the text. The answers must be the result of your own work and decisions. You are prohibited from referring to or copying the answers of others and from giving answers to anyone else taking the course.

SUBMITTING YOUR ASSIGNMENTS

To have your assignments graded, you must be enrolled in the course with the Nonresident Training Course Administration Branch at the Naval Education and Training Professional Development and Technology Center (NETPDTC). Following enrollment, there are two ways of having your assignments graded: (1) use the Internet to submit your assignments as you complete them, or (2) send all the assignments at one time by mail to NETPDTC.

Grading on the Internet: Advantages to Internet grading are:

- you may submit your answers as soon as you complete an assignment, and
- you get your results faster; usually by the next working day (approximately 24 hours).

In addition to receiving grade results for each assignment, you will receive course completion confirmation once you have completed all the assignments. To submit your assignment answers via the Internet, go to:

http://courses.cnet.navy.mil

Grading by Mail: When you submit answer sheets by mail, send all of your assignments at one time. Do NOT submit individual answer sheets for grading. Mail all of your assignments in an envelope, which you either provide yourself or obtain from your nearest Educational Services Officer (ESO). Submit answer sheets to:

COMMANDING OFFICER
NETPDTC N331
6490 SAUFLEY FIELD ROAD
PENSACOLA FL 32559-5000

Answer Sheets: All courses include one "scannable" answer sheet for each assignment. These answer sheets are preprinted with your SSN, name, assignment number, and course number. Explanations for completing the answer sheets are on the answer sheet.

Do not use answer sheet reproductions: Use only the original answer sheets that we provide—reproductions will not work with our scanning equipment and cannot be processed.

Follow the instructions for marking your answers on the answer sheet. Be sure that blocks 1, 2, and 3 are filled in correctly. This information is necessary for your course to be properly processed and for you to receive credit for your work.

COMPLETION TIME

Courses must be completed within 12 months from the date of enrollment. This includes time required to resubmit failed assignments.

PASS/FAIL ASSIGNMENT PROCEDURES

If your overall course score is 3.2 or higher, you will pass the course and will not be required to resubmit assignments. Once your assignments have been graded you will receive course completion confirmation.

If you receive less than a 3.2 on any assignment and your overall course score is below 3.2, you will be given the opportunity to resubmit failed assignments. **You may resubmit failed assignments only once.** Internet students will receive notification when they have failed an assignment--they may then resubmit failed assignments on the web site. Internet students may view and print results for failed assignments from the web site. Students who submit by mail will receive a failing result letter and a new answer sheet for resubmission of each failed assignment.

COMPLETION CONFIRMATION

After successfully completing this course, you will receive a letter of completion.

ERRATA

Errata are used to correct minor errors or delete obsolete information in a course. Errata may also be used to provide instructions to the student. If a course has an errata, it will be included as the first page(s) after the front cover. Errata for all courses can be accessed and viewed/downloaded at:

http://www.advancement.cnet.navy.mil

STUDENT FEEDBACK QUESTIONS

We value your suggestions, questions, and criticisms on our courses. If you would like to communicate with us regarding this course, we encourage you, if possible, to use e-mail. If you write or fax, please use a copy of the Student Comment form that follows this page.

For subject matter questions:

E-mail: n311.products@cnet.navy.mil
Phone: Comm: (850) 452-1572
DSN: 922-1572
FAX: (850) 452-1370
(Do not fax answer sheets.)
Address: COMMANDING OFFICER
NETPDTC N311
6490 SAUFLEY FIELD ROAD
PENSACOLA FL 32509-5237

For enrollment, shipping, grading, or completion letter questions

E-mail: fleetservices@cnet.navy.mil
Phone: Toll Free: 877-264-8583
Comm: (850) 452-1511/1181/1859
DSN: 922-1511/1181/1859
FAX: (850) 452-1370
(Do not fax answer sheets.)
Address: COMMANDING OFFICER
NETPDTC N331
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PENSACOLA FL 32559-5000

NAVAL RESERVE RETIREMENT CREDIT

If you are a member of the Naval Reserve, you will receive retirement points if you are authorized to receive them under current directives governing retirement of Naval Reserve personnel. For Naval Reserve retirement, this course is evaluated at 11 points. (Refer to *Administrative Procedures for Naval Reservists on Inactive Duty*, BUPERSINST 1001.39, for more information about retirement points.)

COURSE OBJECTIVES

When you complete this course, you should be able to:

- identify the missions, functions, and operations of a typical CIC

- identify the CIC officer and enlisted watch stations
- identify the standard CIC displays and status boards and CIC's NTDS functions
- identify and describe the shipboard internal communication systems and their uses
- describe sound-powered phone equipment and demonstrate its proper use
- identify the records and logs used in CIC and the information they contain
- identify the mission-related publications found in CIC, the information they contain, and the requirements for handling and stowing them
- discuss procedures and reports associated with the destruction of classified material
- discuss the basic principles of radar and the basic characteristics of radio waves
- identify and explain the use of basic radar equipment and components
- identify the typical controls found on radar repeaters and state their uses
- identify and give basic interpretations of target indications found on a radar scope
- describe a basic IFF system
- describe how the AIMS Mk XII IFF system operates in normal, emergency, and jamming conditions
- identify and explain the use of shipboard dead-reckoning equipment
- discuss the various types of CIC plots and the associated information that is passed to the bridge
- solve basic maneuvering board problems
- identify the aspects, of charts and their use and maintenance in CIC
- discuss the aspects and performance of search and rescue operations

Student Comments

Course Title: *Operations Specialist, Volume 1*

NAVEDTRA: 14308 **Date**: ____________________

We need some information about you:

Rate/Rank and Name: ____________________ SSN: ____________ Command/Unit ____________________

Street Address: ____________________ City: ____________ State/FPO: ________ Zip ________

Your comments, suggestions, etc.:

Privacy Act Statement: Under authority of Title 5, USC 301, information regarding your military status is requested in processing your comments and in preparing a reply. This information will not be divulged without written authorization to anyone other than those within DOD for official use in determining performance.

NETPDTC 1550/41 (Rev 4-00)

CHAPTER 1

MISSIONS AND FUNCTIONS OF CIC

LEARNING OBJECTIVES

After you finish this chapter, you should be able to do the folloiwng:

1. Identify the primary and secondary missions of CIC.
2. Identify the five functions of CIC.
3. Recognize the various ship-specific CIC operations, including the various watch stations in CIC.
4. Identify the various officer and enlisted watch stations in CIC.

INTRODUCTION

In this chapter, we will explain the missions and functions of CIC. As part of the explanation, we will describe the flow and display of information, CIC control and assist functions, CIC watch stations manned during various evolutions and conditions of readiness, and the recording of information received in and disseminated from CIC. We will also identify, in detail, the duties and responsibilities of CIC personnel.

Before World War II, radar was in its experimental and developmental stages. One of the first ships to have radar installed was the battleship USS *California*. In 1940, the *California*'s commanding officer set aside a compartment for the use of radar personnel, calling it "radar plot." This space served as a clearinghouse for information collected from the radar.

In late 1942, ships equipped with radar had a space set aside and designated as the "combat operations center" (COC). As functions in the COC became more complex, the Chief of Naval Operations redesignated COC as the "combat information center" (CIC), which is its present title.

Today, almost every ship in the fleet has a space designated as CIC. However, no two CICs are exactly alike. As newer equipment and methods of using information obtained from this equipment are developed, the physical designs of CICs change. In each new ship, the size and layout of CIC is based on both the mission of the ship and the CIC equipent installed.

The CIC is predominantly manned by Operations Specialists (OSs). The skills of OSs enable the ship to detect and, subsequently, to engage the enemy.

As an OS, you are in an ever-changing and challenging rating. The Navy is constantly developing new equipment and procedures in communications, radar, and methods of data exchange. All of these new developments are worthless without skilled personnel to use them properly.

Operations Specialist strikers are required to stand watches in CIC on sound-powered phones, radio circuits, status boards, radarscopes, and plotting tables. Aboard some ships, Operations Specialists may also have to stand lookout watches.

As you study this text, keep in mind that your responsibilities as a petty officer break down into two types of duties—military and professional.

You learned—or will learn—your military duties from *Military Requirements for Petty Officer Third Class*, NAVEDTRA 12044 and *Military Requirements for Petty Officer Second Class*, NAVEDTRA 12045. Your professional duties will vary, depending on the type of ship or station you are aboard and on the number of personnel in your division.

As an apprentice Operations Specialist aboard a destroyer, you may be designated as watch PO of an

underway section in CIC. On a carrier, however, you may just be a member of the underway watch team, because carriers normally have sufficient higher rated personnel on board to be watch POs. Additionally, you may be assigned as an instructor in one of the many schools that provide training in subjects dealing with the combat information center. Now, let's identify some of the normal duties an apprentice Operations Specialist might expect to carry out aboard most ships.

Typical duties of an apprentice Operations Specialist:

1. Stand watch on radiotelephone (R/T) nets;
2. Stand watch on sound-powered (S/P) telephones;
3. Operate various types of radar repeaters, including NTDS consoles;
4. Plot on the dead-reckoning tracer (DRT/DDRT);
5. Conduct preventive maintenance on equipment to which assigned; and
6. Be part of the in-port duty section and stand Messenger or Petty Officer of the Watch.

Occasionally, the evaluator, CIC officer, CIC watch officer, or even the captain will ask you for an opinion or recommendation. They <u>must</u> have confidence in your recommendations, so <u>you</u> must have the ability and confidence to give recommendations.

To remain effective, a ship must be able to defend itself. The burden of defense rests squarely on early warning from air and surface radars or electromagnetic detection equipment. It is vital, therefore, that you understand that this responsibility is directly on your shoulders. All of our newly acquired missiles and rockets are of no practical value unless Operations Specialists detect the enemy.

MISSIONS OF CIC (U)

The primary mission of CIC is to provide organized collection, processing, display, competent evaluation, and rapid dissemination of pertinent tactical information and intelligence to command and control stations. CIC is responsible for keeping "conn" advised at all times of the current tactical situation. "Conn" may be the commanding officer or someone who has been delegated as the C.O.'s representative (ordinarily the OOD).

A second but equally important mission of CIC is to control or assist in specific operations delegated by proper authority. CIC may be called upon to exercise direct control of various situations and operations, such as:

- Electromagnetic radiation control (EMCON)
- Air control
- Small craft control
- Tactical maneuvers
- Internal and external communications
- Maneuvers for own ship during a man overboard situation
- Information documentation

CIC may also be charged with assisting and coordinating with other internal or external agencies during the following evolutions:

1. Navigation and piloting
2. Undersea warfare operations
3. Air warfare operations
4. Surface warfare operations
5. Missile defense
6. Target indication, designation, and acquisition
7. Shore bombardment
8. Search and rescue operations
9. Amphibious operations
10. Mine warfare
11. Electronic warfare

We will discuss these operations, situations, and evolutions briefly below and in greater detail later in this manual and its associated manual (volume 2).

Emission Control

Emission control (EMCON) is one of the major aspects of your electronic warfare job. CIC is the EMCON control center on most ships. To perform satisfactorily, you must study and learn your ship's EMCON doctrine and EMCON bill. When EMCON conditions are set or changed, you and your fellow Operations Specialists will be responsible for ensuring that the current EMCON condition is set in CIC.

Air Control

Air control is the guidance and assistance given to aircraft by personnel not actually engaged in the flight. Such personnel, known as "air controllers", are specially trained to control assigned aircraft by the use of radio, radar, or other means. For the most part, control is the immediate passing of information and directions by radiotelephone from the controller to the pilot during the mission.

The publications *Standard Organization and Regulations of the U.S. Navy*, OPNAVINST 3120.32 and *CV NATOPS Manual*, NAVAIR 00-80T-105 assign the responsibility for tactical and mission control of aircraft during assigned missions to the CIC officer. This includes providing separation from other traffic operating in the vicinity of a carrier and ensuring that mission controllers know the basic procedures for air traffic control. In addition to controlling assigned missions, the CIC officer ensures that the controllers know their responsibility for traffic advisories to aircraft operating in visual conditions and for safe separation of aircraft operating in instrument conditions. Upon request, the CIC officer provides the air controllers with information concerning areas of special operations such as air-to-surface weapon drops and air-to-air missile shoots.

Q1. What is the primary mission of CIC?

Q2. List five secondary missions of CIC.

In most cases, the CIC takes control of the aircraft from a land-based traffic control agency, an air control agency, or a carrier-based flight control agency. When the aircraft's mission with CIC is finished, the CIC mission controller gives control of the aircraft to the air control agency that will guide the aircraft to the next area of operations or to its home base. CIC mission controllers should track or monitor the approaching or departing aircraft as long as possible, even when it is under control of another agency. Should the aircraft have an emergency, the CIC mission controller will be ready to give any necessary assistance to the aircraft or to the rescue craft.

Controlling Small Craft

CIC may be called upon to control boats or small craft whenever CIC personnel could do a better or more efficient job than anyone on board one of the boats or craft. One common example is when restricted visibility requires that boats be directed by use of shipboard radar. Another example is when boat operations are governed by complex tactical situations that require the capabilities of a ship's CIC, such as during an amphibious operation. In all cases, CIC personnel must be familiar with the radar reflectivity of the small boats under its control. CIC must also have accurate charts annotated to show safe channels, boat lanes, etc. Finally, CIC personnel must be familiar with the capabilities and limitations of the boats or craft to be controlled, including their seaworthiness.

Tactical Maneuvers

Whenever two or more ships are in formation or maneuver near one another, CIC maintains a plot of all associated ships, solves relative movement problems for changing stations, and makes recommendations to conn for appropriate course and speed changes. Also, CIC tracks all unidentified contacts and advises conn frequently concerning the latest tactical developments.

Communications

CIC personnel use both internal and external communications during every type of mission or assignment.

Internal communications provide a means for exchanging information between the various compartments and stations throughout the ship. We will cover internal communications extensively in chapter 3 of this manual.

External communications provide a means for exchanging information between own ship and some outside point. We will discuss external communications in chapter 1 of volume 2.

Man Overboard

All Operations Specialists <u>must</u> know what to do when a "Man Overboard" alert sounds, since the more rapid the response, the greater the chance of a successful recovery. Because no two ships are identical, each ship has its own recovery procedure. You must, therefore, read your ship's CIC doctrine and the CO's standing orders to ensure that you fully understand all recovery procedure requirements.

Information Documentation

To operate efficiently and effectively, CIC must maintain various records and logs and make certain reports. You, as an Operations Specialist, must know

the essentials of maintaining the required logs, records, files, and publications. We will discuss CIC logs, records, and publications in chapter 4 of this manual.

Navigation and Piloting

Although CIC cannot relieve the navigator of responsibility for the safe navigation of the ship, it is still charged with providing him with every bit of information that can be obtained by electronic means. Radar is the primary source of such electronic information and is used extensively during every departure, entry, or anchoring evolution.

Whenever you use a navigation chart, you must take radar fixes at least every 3 minutes (normally every 2 minutes in restricted waters and 1 minute in reduced visibility) and recommend courses of action to the navigator, based on positions obtained by radar.Anti submarine Warfare Operations

Anti submarine Warfare Operations

One of the primary threats facing all ships on the high seas is potential attack by submarines. Consequently, it is extremely important to use all available assets to counter this threat.

The purpose of anti submarine warfare (ASW) operations is to deny the enemy the effective use of its submarines. In these operations, the role of CIC is to give all possible assistance to the ASW evaluator/tactical action officer (TAO) by carrying out its functions of information handling, assistance, and control.

CIC correlates, on a geographic plot, all the sonar contact information, the radar positions of assisting ships and ASW aircraft, and any ASW action taken. The evaluator/TAO in CIC will take control of the ship's maneuvers when the ship is prosecuting a submarine contact. ASW aircraft are usually controlled by an Operations Specialist known as the *antisubmarine air tactical controller* (ASTAC).

Air Warfare Operations

Air warfare (AW) is the action required to destroy or to reduce the enemy's air and missile threat to an acceptable level. It includes such measures as the use of interceptors, bombers, antiaircraft guns, surface-to-air and air-to-air missiles, and electronic countermeasures, and the destruction of the air or missile threat, either before or after it is launched.

CIC becomes the focal point during air warfare operations. Incoming raids are plotted on large, edge-lighted, vertical plotting boards or presented on NTDS consoles. The evaluator/TAO uses the plotted information to determine and counter the most threatening raid. Information on raids is received from the ship's radar, voice radio nets, lookouts, electronic warfare equipment, and data links. One of the weapons available to the evaluator/TAO is the interceptor controlled by an Operations Specialist.

Surface Warfare Operations

CIC is continuously involved with surface tracking, if for no other reason than to avoid collisions. Surface tracking is vitally important during Surface Warfare (SW) operations, when course and speed computations on enemy surface units are needed for maneuvering decisions to counter the threats. CIC personnel plot surface contacts on the DRT/DDRT tracking systems (explained in the plotting chapter) or track them on a surface NTDS console, plot enemy units on the strategic plot, and maintain surface status boards. They also make recommendations to the evaluator/TAO and the bridge on weapons assignment and tactics. Attack aircraft, controlled by an Operations Specialist, are primary weapons against fast patrol boats.

CIC also maintains the surface, subsurface, surveillance coordination (SSSC) plot of all enemy and friendly units on a small-scale gridded chart or on an NTDS console.

Target Indication, Designation, Acquisition, and Anti-ship Missile Defense

CIC is responsible for the ship's defense against incoming missiles and low flying aircraft. Because of the speed of these targets, CIC must coax the fire control radars onto them rapidly and accurately; reaction time is critical.

Whenever a threat target approaches, CIC alerts the fire control directors and begins reporting frequent positions as soon as the target enters fire control radar range. CIC continues tracking the target until it is no longer a threat. By acquiring target rapidly, CIC allows the weapons crews (guns or missiles) to destroy it at the greatest possible distance from the ship.

CIC must also notify the electronic warfare personnel to employ electronic protection (EP) measures to counter the incoming threat. Some of the

protective measures available are SRBOC and TORCH CHAFF and RUBBER DUCK decoys.

Shore Bombardment

Close coordination between CIC and gunnery stations is vital to completing naval surface fire support (NSFS) missions successfully.

The mission of CIC during gunfire support evolutions is to supply information to, and to conduct radio communication for, the involved gunnery stations. CIC has the following basic responsibilities in gunfire support:

1. Maintaining an accurate geographic fix of own ship's position
2. Determining the effects of wind, tide, and current on own ship's movement, thus determining course and speed made good
3. Establishing and maintaining communications with the shore fire control party, using procedures outlined in *Allied Naval Gunfire Support*, ATP 4 and *Amphibious Operations—Ship-to-Shore Movement*, ATP 37
4. Providing necessary information to gun plot to obtain computer checks (offsets to Point Oscar) every 15 seconds, or as requested, until a computer solution is obtained prior to reporting on station
5. Receiving, recording, and relaying fire requests
6. Locating the target, checking its height, plotting friendly front lines, and relaying the data to weapons plot
7. Receiving from gun plot the gun target line, time of flight, and height of trajectory of the shot
8. Relaying fire orders from the spotter
9. Converting spots to deflection and elevation changes in relation to own ship

These actions are used with rectangular coordinate computers. Not all ships are so equipped. To determine the type of equipment available and the procedures used aboard your ship, consult the CIC doctrine or a similar shipboard publication.

Search and Rescue Operations

The primary purpose of search and rescue operations is to save lives, whether the distress situation involves an immediate danger or a problem that might deteriorate into an immediate danger. Therefore, you must quickly obtain a bearing and range to the emergency IFF using radar/IFF presentations or a bearing to the voice distress if communications direction finding (DF) equipment is available. The initial, and therefore ultimate, responsibility rests on those first aware that another human being is in distress and needs assistance.

As an Operations Specialist, you may well be the first person to become aware of a distress situation. You <u>must</u> be prepared to react accordingly. An emergency IFF response or a transmission on one of the voice radio distress circuits may last only a few seconds. Therefore, you must quickly obtain a bearing and range to the emergency IFF, or a bearing (using radio direction-finding equipment in CIC) to the station transmitting the distress signal by voice radio.

You may also discover an emergency by overhearing an emergency signal on the voice radio circuits you are guarding in CIC. The following distress voice radio signals indicate the type of emergency situation.

1. PAN PAN: — The international radiotelephone urgency signal meaning the calling station has a very urgent message to transmit concerning the safety of a ship, aircraft, or other vehicle; or the safety of a person.
2. MAYDAY: — "Mayday" spoken three times and followed by the aircraft's call sign means the pilot is threatened with danger and needs help immediately.

Obtaining an accurate position of a unit in distress is vital, because all search and rescue (SAR) operations are based upon the last-known position.

CIC is the coordinating station for all air, surface, and subsurface search and rescue operations, and is responsible for the following actions:

1. Recommending courses and speeds to the scene, search plans, and procedures to be followed throughout the operations

2. Establishing and maintaining communications on all SAR voice radio circuits

3. Providing conn and all other interested stations with all available information pertaining to the SAR incident, including the description, capabilities and limitations, and characteristics of the platform in distress

4. Keeping thorough navigational, RT, and watch log entries of the events as they occur

You can rarely anticipate a SAR incident. Therefore, you must have a thorough knowledge of the SAR procedures as outlined in the CIC doctrine for your particular ship. You must be prepared to act quickly and correctly, because in every SAR operation human lives are at stake.

In addition to discovering someone requiring SAR support, you may also discover a lost aircraft on a radar scope. A lost aircraft that has voice communications problems will fly a triangular pattern. If the aircraft has only a receiver , the pilot will switch to one of the distress frequencies and fly a *right-hand* triangular pattern, squawking an appropriate IFF lost-communications code. If the aircraft has no receiver, the pilot will fly a *left-hand* triangle, again squawking an appropriate IFF code for lost communications. See figure 1-1.

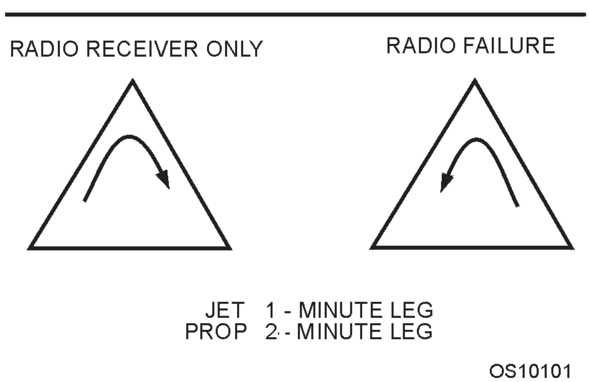


Figure 1-1.—Triangular patterns.

Any time you observe an aircraft flying a triangular pattern; report the aircraft's position immediately to your watch supervisor.

Amphibious Operations

Amphibious operations involve the movement of troops, supplies, and vehicles from ship to shore.

One of the most important phases of an amphibious operation is the ship-to-shore movement, in which the assault troops and their equipment are deployed from assault ships to designated areas ashore. Troops are carried by landing craft, amphibious vehicles, or helicopters. One function of an OS is to control the landing craft, including craft acting as wave-guides for amphibious vehicles.

Mine Warfare

Mine warfare has always been a part of naval warfare tactics. The types of mines and their uses have changed considerably, as have the platforms that remove the mines from harbors and coastal areas when they are no longer useful or needed. Operations Specialists are concerned with the removal operations.

Until 1971 all minesweeping was conducted by wooden-hulled boats and ships, which steamed through the minefield trailing special minesweeping gear behind them. In 1971, the helicopter came into use as a minesweeping platform. This increased the crew's mine sweeping speed and decreased the danger from exploding mines.

The helicopter was first used as the primary sweep platform during mine clearing operations in the harbors and inland waters of North Vietnam. This operation proved that the helicopter was an efficient minesweeping platform. Later, operations were conducted to clear mines in the Suez Canal and the Bitter Lakes. Here again, the value of the helicopter was proven.

To ensure continuity and safety of flight in helicopter minesweeping operations, the Chief of Naval Operations established the requirement for specially-trained shipboard mine countermeasures helicopter air controllers (MCMHC). This requirement ultimately was tasked to the Operations Specialist rating on board designated mine warfare ships.

Operations Specialists also control minesweeping boats in and around amphibious operations.

Electronic Warfare

Electronic warfare (EW) is defined as a military action that uses electromagnetic energy to determine, exploit, reduce, or prevent hostile use of the electromagnetic spectrum. At the same time, EW retains friendly use of the electromagnetic spectrum.

OBJECTIVES OF ELECTRONIC WARFARE.—The objectives of naval EW, in conjunction with other actions, are as follows.

- To ensure the continued freedom of the seas by providing operational commanders with the capability to take action using the electromagnetic spectrum
- To be aware of and to counter hostile intent

- To protect friendly forces

These objectives include

1. determining the existence, location, make-up, and threat potential of all weapons, sensors, and communications systems that use electromagnetic radiation;

2. denying the enemy the effective use of his electromagnetic systems by destroying or degrading them; and

3. insuring the effectiveness and security of friendly electromagnetic capability.

DIVISIONS OF ELECTRONIC WARFARE.—Electronic warfare is broken down into the following three divisions:

- Electronic warfare support (ES)
- Electronic Attack (EA)
- Electronic protection (EP)

EW consists of operations and tactics that decrease the enemy's use of electronic systems, enhancing the friendly use of the electromagnetic spectrum. Friendly forces conduct EW by performing the following actions:

- Intercepting enemy emissions (including electromagnetic, acoustic, and electro-optical).

- Exploiting enemy emissions by extracting intelligence through classification, location, identification, and other processing actions. Exploitation, to some degree, is almost always a continuation of interception, except when interception is done only to collect intelligence. Hull-to-emitter correlation (HULTEC) is one aspect of exploitation in which various parameter measurements are correlated to provide specific platform identification.

- Degrading the electronic capability of enemy forces by jamming, electronic deception, and use of decoys.

- Protecting own forces from interception and exploitation and from targeting of electronic emissions by anti-radiation missiles (ARM) and other passive weapons guidance systems. EP also ensures the use of friendly sensors despite the hostile use of ES.

EW development paralleled the application of electronics to naval warfare. The invention of the wireless, the vacuum tube, and the magnetron; the development of radar and lasers; and the introduction of solid-state technology are among the obvious advances that have had an immediate and significant impact on EW development and growth.

FUNCTIONS OF CIC

Recall from the beginning of this chapter that the primary mission of CIC is handling information. Information handling is composed of five major functions—gathering, processing, displaying, evaluating, and disseminating information and orders. Information handling is a continuous and growing process that ultimately furnishes a composite picture of a situation, enabling the commanding officer to make a final evaluation and give orders for action. The following is a brief discussion of each of the major CIC functions.

GATHERING INFORMATION

"Gathering" is the collecting of combat information from various sources. Many sources are available, but CIC must use at least those listed below to attain maximum effectiveness.

- Radars
- Voice radio
- Radio messages
- Electronic warfare equipment
- IFF
- Sonar
- Depth sounder
- Tactical data systems
- Tactical data systems
- Visual sources, such as optical rangefinders, lookouts, signal bridge, and conn
- Internal sources, such as sound-powered telephones, MC units, ship's service telephone, and messengers
- Intelligence reports
- Publications, such as the NWP, NWIP, ATP, and ACP series
- OpPlans and OpOrders

- Charts and navigational data
- Aerological observations, reports, and forecasts
- Current instructions, notices, and directives
- Satellite and radio data-link systems

PROCESSING INFORMATION

After gathering or receiving combat information, CIC must process it to eliminate nonessential information. "Processing" consists of sorting, inspecting, appraising, and correlating all information so the resulting filtered information may be displayed and disseminated as necessary.

DISPLAYING INFORMATION

CIC displays information by several means and on several devices. The primary means and devices are listed below.

- Summary plots
- Status boards
- Surface plots
- Strategic plots
- Geographic plots
- ACDS/NTDS/AEGIS consoles
- Maps and charts
- Television
- Logs and records
- Large-screen displays (LSD)

Q3. What are the five major functions of CIC?

EVALUATING INFORMATION

"Evaluating" is the process of considering and weighing all available information to arrive at a sound operational decision. CIC may then either act on the decision or passed it on as a recommendation to command and other appropriate stations. In addition, CIC evaluates the information to provide a comprehensive tactical picture to the command.

DISSEMINATING INFORMATION

"Disseminating" is the process of distributing evaluated information to the various control stations and others throughout the ship who need to know. Evaluated information must be disseminated in a clear, concise manner through the most appropriate means of communication.

CIC MANNING

In this section, we will provide a general discussion of CIC manning during the various CIC watches, details, and operations. For specific information, consult your ship's combat systems doctrine or CIC doctrine .

PREPARATIONS FOR GETTING UNDER WAY

Members of CIC have many duties to perform before getting under way. Regardless of what your assignment is, be sure to use the appropriate checklist, since there are too many things to do for you to rely on your memory.

SPECIAL SEA DETAIL

The special sea detail is set and stations are manned when a ship leaves or enters a port or anchors. OSs man stations assigned by the watch, quarter, and station bills and perform duties described in the ship's CIC doctrine.

Because there are potential dangers when a ship is leaving and entering a port, sea detail stations are manned by the most qualified personnel.

CIC AT ANCHOR

Occasionally, when the ship is anchored, CIC may need to be partially manned to furnish the OOD with information related to the safety of the ship. This watch is called the *anchor watch*.

During the anchor watch, you will use the surface search radar to obtain ship's position fixes at times prescribed by the CIC doctrine. After you obtain a radar fix, you will compare your radar fix with the fix determined visually by the quartermaster of the watch (QMOW). If the two fixes indicate that the ship has moved from its assigned anchorage, the QMOW will notify the OOD immediately and give him complete information about the ship's true position. The QMOW will also notify the OOD if the ship has not moved.

BATTLE GROUP OPERATIONS

When you are steaming in a task force, the ship's size, type, mission, and maneuverability come into play. Task force steaming can vary from simple line formations to complex AW dispositions.

As an OS, you must know the type of formation you are in, ships in company, station assignment, maneuvering instructions, and your ship's tactical data.

We will discuss operating forces, type organization, task organization, formations, and rules governing task force steaming in detail in chapter 11.

CONDITIONS OF READINESS

Conditions of readiness permit the ship to conduct its assigned mission effectively. The commanding officer or his direct representative will set a specific readiness condition, depending on the tactical situation. There are three basic conditions of readiness: I, III, and IV.

Condition I

When condition I is set, the ship is at General Quarters, with all hands at battle stations and all equipment lighted off and ready for instant action. General quarters (GQ) may be set at any time, in port or under way. GQ is sounded whenever battle is imminent or when the highest state of readiness to meet an emergency is necessary. The maximum crew endurance in condition I is 24 hours.

There are different conditions of readiness for General Quarters—1AA, 1AS, and 1A. Condition 1AA is battle stations to counter an air threat. Condition 1AS is battle stations to counter a submarine threat. Condition 1A is amphibious battle stations.

Condition III

Condition III is set for wartime steaming. During condition III, one-third of the crew is on watch and only certain stations are manned or partially manned. Condition III is set when attack is possible. The maximum crew endurance in condition III is from 1 to 60 days.

By being at condition III, the ship can engage a threat and still have time to go to condition I.

Condition IV

Condition IV is set for normal peacetime steaming. During condition IV, only necessary personnel are on watch, with the remainder performing work or training. The maximum crew endurance in condition IV is unlimited.

PERSONNEL ASSIGNMENTS

The CIC, like other ship organizations, has specific positions to which its members are assigned. These assignments are listed and defined in the combat systems doctrine, also known as the CIC doctrine. The CIC doctrine is a chief source of information for indoctrinating new personnel in CIC operations. The objective of the CIC doctrine is to put in writing the correct procedures and organizational structure of the CIC. Figure 1-2 shows an example of the CIC organization within the operations department.

The CIC doctrine normally contains all the operational, training, emergency, and destruction bills to which Operations Specialists may be assigned. It also lists the duties and responsibilities of the officer and enlisted personnel assigned to CIC.

OFFICER STATION ASSIGNMENTS

There are a variety of officer station assignments, or positions, in a typical CIC aboard a large combatant ship. The primary duties of those stations are described below.

- Evaluator/tactical action officer (TAO). — The evaluator/TAO acts as direct advisor to command from the display and decision (D&D) area and must be kept informed of the general tactical situation in order to make the best evaluation of the information available in CIC.

- Assistant evaluator/TAO. — Normally, the CIC officer acts as assistant evaluator/TAO and is responsible for the coordination of all CIC functions. The assistant evaluator/TAO also monitors communications (internal and external) and assumes the duties of the evaluator/TAO when directed by higher authority.

- Ship's weapons coordinator. — The ship's weapons coordinator (SWC) acts as liaison between the weapons control station and CIC, using various means of communications. The SWC keeps weapons control informed of possible missile targets, assists the weapons stations in acquiring designated targets, and

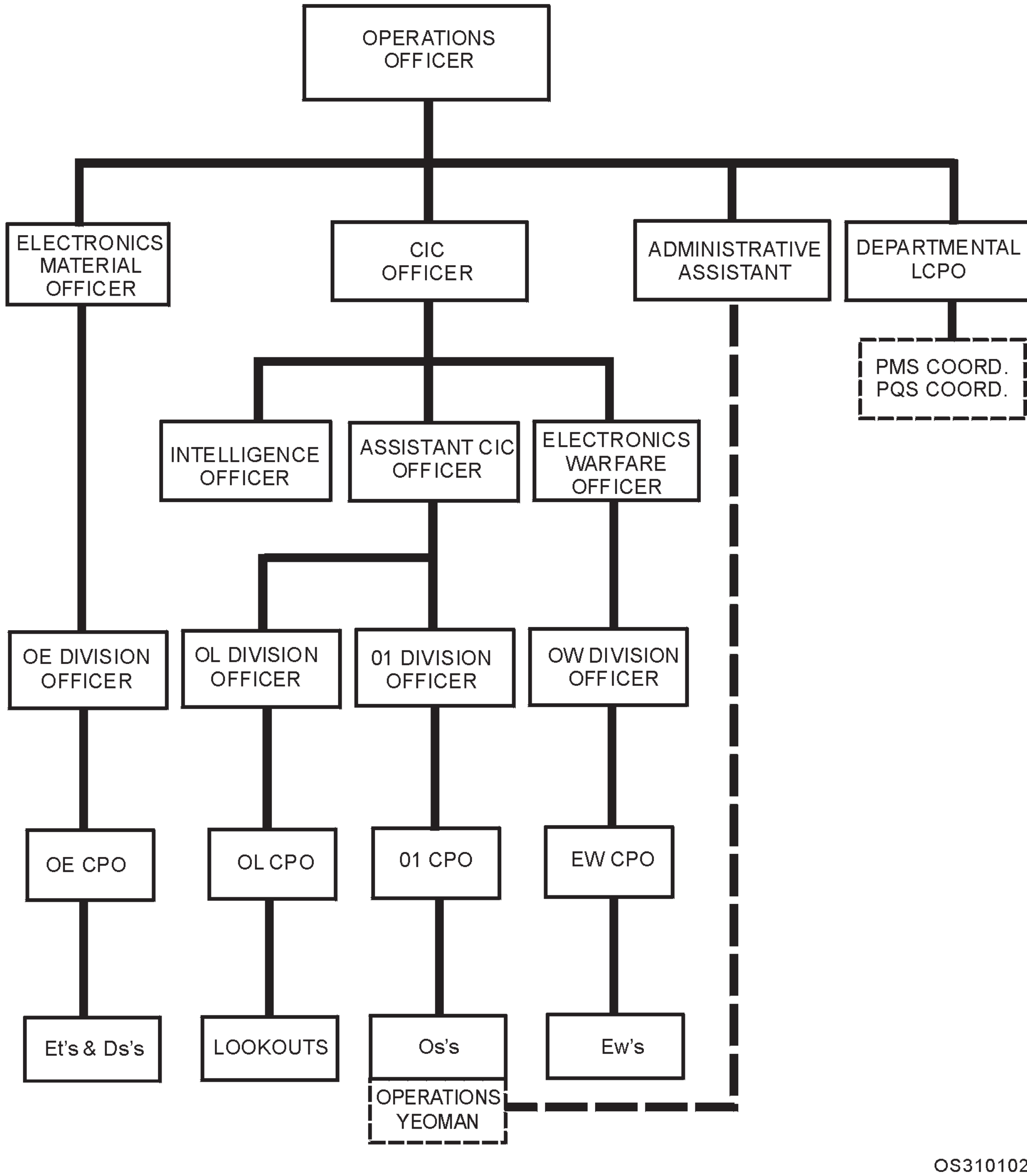


Figure 1-2.—Example of the CIC organization within an operations department.

advises the evaluator/TAO of the operational and material status of all weapons systems.

- Gunnery liaison officer. — The gunnery liaison officer (GLO) acts as liaison between weapons control and CIC during surface engagements and shore bombardment operations (NSFS). The GLO keeps weapons control informed of possible targets and assists in acquiring targets.

- Surface watch officer.—The surface watch officer coordinates all surface and tactical information, makes recommendations to the evaluator/TAO and to conn, and supervises the collection and display of all available information on surface contacts.

- Electronic warfare officer.—The electronic warfare officer (EWO) supervises the collection and display of all available EW information and makes preliminary evaluations to ensure that only electronic emissions not positively identified as friendly are displayed. The EWO also ensures immediate dissemination to the evaluator/TAO of any threat emitters detected and initiates countermeasures as directed by higher authority.

- Piloting officer .—The piloting officer supervises the radar navigation team to ensure accurate and prompt fixing of the ship's position by using all electronic means available. He advises conn of the ship's position, recommended courses and times to turn, position of geographic and navigational objects in the

vicinity of the ship, and any potential navigational hazards. The piloting officer recommends alternate tracks, if available, to the navigator and conn when the primary track is blocked or made hazardous by the presence of shipping or other contacts.

- Shipping officer.—The shipping officer advises conn of the position, course, speed, and closest point of approach (CPA) of all surface contacts in the area, with particular emphasis on small craft appearing at short range and contacts that have changed course or have erratic courses and speeds.

Q4. What are the three basic conditions of readiness?

ENLISTED STATION ASSIGNMENTS

Enlisted personnel function as plotters, radar and repeater operators, status board keepers, and talkers. The following are examples of several enlisted station duties. All of these stations are not necessarily used on all ships.

- DRT/DDRT operator.—The DRT/DDRT operator maintains a comprehensive geographic plot of own ship's track, other surface contacts, and any assigned shore bombardment targets.

- Surface search radar operator.—The surface search radar operator tracks and reports all surface contacts, using proper designations; manipulates the surface search radar controls to maintain the radar in peak operating condition; and reports positions of ASW aircraft and assist ships to the DRT/DDRT plotter.

- Navigation radar operator.—The navigation radar operator reports navigation points to the navigation plotter to obtain fixes.

- Surface summary plotter.—The surface summary plotter maintains the surface summary plot as directed by the evaluator/TAO and records each contact's course, speed, and CPA on the plot, in less automated CICs.

- Navigation plotter.—The navigation plotter uses the information provided by the navigation radar operator to accurately plot and maintain the position of own ship on the appropriate chart during radar navigation.

- Surface status board plotter.—The surface status board keeper plots information received from the surface search radar operator, DRT/DDRT operator, surface supervisor, and other plotters.

- Detection and tracking (D&T) supervisor (Track Sup).—The detection and tracking supervisor supervises the complete air picture, including the air search operator, trackers, and coordinates the transfer of detected targets to tracking operators; and supervises the use of EP features as directed by the EWO or evaluator/TAO.

- Air search radar operator.—The air search radar operator conducts air searches as directed by the evaluator/TAO, under the supervision of the D&T supervisor, and manipulates the air search radar controls as necessary to maintain peak operating efficiency.

- Identification operator.—The identification operator attempts to identify all air contacts as they appear on the air summary plot, alerting the evaluator/TAO if unopposed raids enter the ship's area of responsibility or missile envelope.

- Air intercept controller.—The air intercept controller is responsible for the positive control of all aircraft assigned for any aircraft mission. When in control of CAP and when the CAP is not otherwise engaged, the air controller initiates intercepts of targets-of-opportunity.

- Radiotelephone talkers.—Radiotelephone talkers transmit and receive tactical and contact information on various R/T nets.

- R/T net plotters.—R/T net plotters plot information received from other ships on the various plots and status boards.

- Sound-powered-phonetalkers.—Sound-powered (S/P) phone talkers pass information to and from CIC and other stations throughout the ship on various S/P circuits (JA, 1JS, JL, 1JV, JX, etc.).

- Electronic warfare supervisor.—The electronic warfare supervisor supervises the EW operators and assists the EWO in evaluating intercepted electronic emissions.

- R/T net recorders.—The R/T net recorders record in logs all transmissions received on the various R/T nets.

The normal steaming watch in the CIC of a typical CG usually consists of nine enlisted stations and one officer station, as follows:

- CIC watch officer
- CIC watch supervisor
- Surface search radar operator (surface tracker)

- Surface status board plotter
- DRT operator
- Air search radar operator (air tracker)
- Air summary plotter (on non-NTDS ships)
- R/T net talker
- S/P telephone talkers (2)

Additional Operations Specialists may have to be called in for special operations.

The normal steaming watch on a destroyer may consist of only one officer and four or five enlisted personnel, with the Operations Specialists doubling up on some of the stations shown above.

Q5. *What CIC officer acts as a direct advisor to the command?*

ANSWERS TO CHAPTER QUESTIONS

A1. *To provide organized collection, processing, display, competent evaluation, and rapid dissemination of pertinent tactical information and intelligence to command and control stations.*

A2. *Electromagnetic radiation control (EMCON), air control, small craft control, control of tactical maneuvers, internal and external communications, control of own ship during a man overboard situation, information documentation.*

A3. *Gathering, processing, displaying, evaluating, and disseminating information and orders.*

A4. *I, II, and IV.*

A5. *Evaluator/tactical actions officer (TAO).*

CHAPTER 2

CIC DISPLAYS

LEARNING OBJECTIVES

After you finish this chapter, you should be able to do the following:

1. Identify standard CIC displays.
2. Identify the standard CIC status boards.
3. State the various NTDS functions.

INTRODUCTION

Recall that the primary mission of CIC is to gather and process information. Once information is processed, it must be presented to its users. In CIC, most tactical and strategic information is presented in an orderly manner on display boards. This enables the evaluator and other key personnel to analyze the information and to determine the relative priorities of operational threats and opportunities.

This section deals with the means available for displaying information, as well as the distribution and arrangement of summary boards, status boards, plots, etc., within a typical CIC. Detailed plotting procedures and the symbology to be used are discussed in the chapter on plotting.

CIC PLOTS

Displays in CIC may be arranged in any number of ways, depending on the mission of the ship. For example, an ASW (antisubmarine warfare) ship will have many more ASW displays than a ship that is primarily concerned with AW (aircraft warfare). Some destroyers will have fewer displays, while aircraft carriers will have more. The most common types of displays follow.

STRATEGIC PLOT

The strategic plot is a large area, true display showing the position, movement, and strength of own and enemy sea, land, and air forces within a prescribed area of operations. This display is maintained on hydrographic charts of suitable scale. Information for the strategic plot is taken from operation plans and orders, intelligence data, and reports of reconnaissance missions. The strategic plot is used in planning present and future operations and in making decisions. These plots should contain the location of own and enemy submarines, own submarine restricted areas, enemy missile-launching sites (including all data on type and numbers), and other strategic data that may affect the tactical situation.

GEOGRAPHIC PLOT

The geographic or navigational plot is a true display of the position and tracks of friendly, enemy, and unidentified surface, subsurface, and certain air contacts. It is maintained on the dead-reckoning tracer (DRT) plotter and is also displayed on the NTDS (discussed later in this chapter) console on NTDS-equipped ships. Ships equipped with the AEGIS display system (ADS) can display the geographic plot on large-screen displays (LSD). Geographic reference points and other objects requiring display of true positions are plotted. Although specific uses of the plot vary with the tactical situation, the plot is required for station keeping, coordination of search and rescue, radar piloting, shore bombardment, weapons liaison, undersea warfare, and surface warfare. The DRT/DDRT plotting sheet is a valid log. If you become involved with it, take care in preparing and maintaining it. Some evolutions require that it be preserved for future evaluation.

AIR SUMMARY PLOT

During air warfare operations, the *air summary plot* is the main display in a conventional ship, as is the NTDS console on an NTDS-equipped ship. See figure 2-1. Air plotting is normally done on a 60-inch, edge-lighted, vertical plotting board, etched with a polar coordinate grid (bearing lines and range circles) and superimposed with a Cartesian grid. (Grid systems are discussed in chapter 12) Because of the uniqueness of the grids and the vertical plot, the range scale is unlimited. Any range scale desired can be used. Normally for air plotting, the plot should cover an area having a radius of at least 200 miles from own ship. Position information in range and bearing is transmitted through sound-powered phones from the air-search radar operator to the plotters behind the board, who write backward on the board and plot with a grease pencil. The Cartesian grid is also used to plot position information on contacts that are being reported by other ships within the force. Any reported contacts that are within the range coverage of the plot but not held on own ship's radars are displayed on the front of the board by the radiotelephone (R/T) plotter. (These communication circuits are discussed in a later chapter.) The functions of the air summary plot are as follows:

- Provide an opportunity for the evaluator/TAO and the radar control officer (RCO) to decide the proper designation of an air contact
- Provide the air intercept controller with information on the location of a contact to be intercepted
- Provide a display of the position of other ships and of the combat air patrol (CAP) so that the

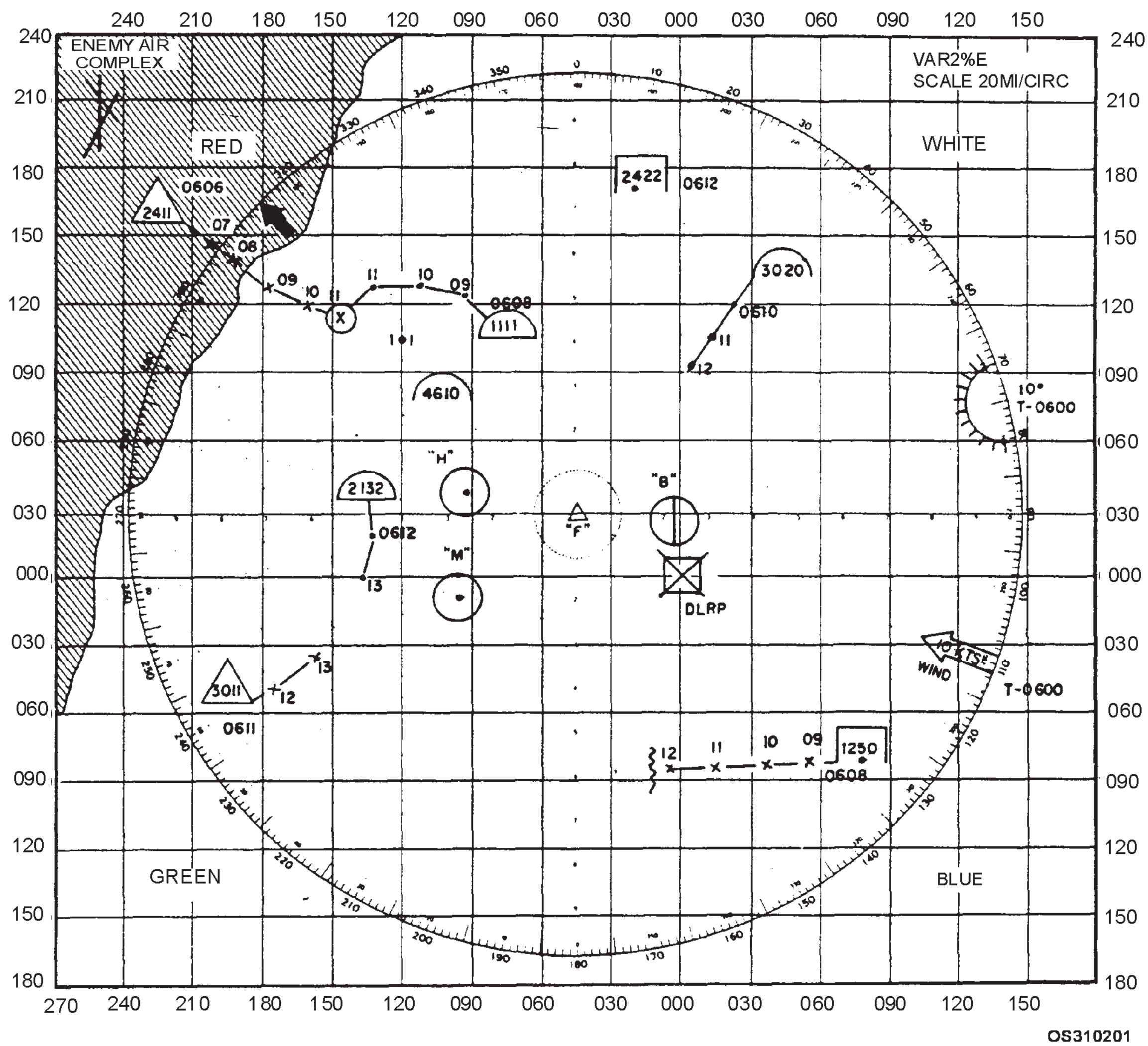


Figure 2-1.—Example of an air summary plot.

best possible coordination can be achieved between CAP and air control ships

- Provide a display from which the R/T talker can make reports to other units of the force
- Provide advance information to the weapons liaison officer concerning possible weapons targets

The air summary plot is one of the evaluator's/TAO's most valuable tools. When this plot is maintained properly, the evaluator/TAO does not need to look at a radar scope, and should never "lose the picture." Some of the information that should be plotted on the air summary plot is as follows:

- Distance scale
- Sun/Moon bearing, position angle, and time
- Magnetic variation
- Position of other units within the force
- Friendly and/or enemy land, including airfields
- CAP stations
- All friendlies held on own radar
- AEW/ASW aircraft tracks
- Search sectors
- All contacts appearing on the air-search radar and those reported on radiotelephone
- Fades
- Aircraft reported by lookouts
- Weapons warnings and conditions as appropriate
- Enemy electronic emissions
- Intelligence information, such as air lanes, enemy military complexes, unidentified and hostile submarines, air navigation danger areas, and any other tactical data of importance.

One to six plotters may be used to man the air summary plot, depending on the situation. When only one plotter is used, he or she mans the air search S/P circuit and works behind the board, plotting all contacts held by own ship's radars. If there is a second plotter, the plotting assignment should be divided into east-west areas. A third plotter may be assigned as a friendly contact plotter. Information reported by other ships is plotted on the front of the board by the R/T plotter and/or the link 14 plotter. When there is a shortage of personnel, the R/T talker may double as a plotter.

SURFACE SUMMARY PLOT

The surface summary plot is a comprehensive relative display of positions and tracks of friendly, enemy, and unidentified surface and subsurface targets. It also shows geographic points and any other data required for a better understanding of the complete surface picture. This plot should reflect the situation as seen on the PPI scope, with the addition of identification and projected track data. Own ship is the center of the plot.

During operations, the surface summary plotter wears sound-powered telephones and is in communication with the surface search radar operator, DRT plotter, and surface status board plotter. Normally the surface summary plotter stands behind the board and maintains an accurate plot of the positions of all other ships in the formation relative to own ship, which is in the center. He or she also keeps an accurate relative track of all surface contacts within range, plotting bearings and ranges of contacts furnished by the surface search radar operator or by the remote PPI scope operator. As a contact moves, the surface summary plotter connects the successive plotted positions of each separate contact to show the relative track or relative movement line. In other words, by using standard symbols and abbreviations, the plotter displays on the summary plot the same picture indicated by the PPI scope. The plotter also records the course and speed of all contacts solved by the DRT operator, as well as bearing, range, and time of CPA as figured by the surface plotter.

FORMATION DIAGRAM

The formation diagram and the surface plots are routine displays in CIC for all tactical exercises and operations. Every member of the CIC team must become familiar with their composition and use. This knowledge is necessary because these plots, along with the geographic plot, associated status boards, navigational charts, and surface search radar, are the main tools of the CIC team in surface tactics. The formation's center is the center of the plot.

The formation diagram is a display, kept in polar coordinates, of all stations in a formation of ships. On the formation diagram, all ships in the main body are displayed relative to the formation's axis and center. Screen sectors are assigned by true bearings and

ranges. The formation diagram is a valuable aid in determining the positions of new stations in formation and screen maneuvers. Also, it assists in displaying the formation on the surface plot.

The desirable manner for displaying the formation diagram is on a vertically mounted, edge-lighted, polar coordinate plotting surface. Because of the limited space on many ships, however, this plot sometimes is kept on a maneuvering board.

Q1. What plot provides a large area, true display showing the position, movement, and strength of own and enemy sea, land, and air forces within a prescribed area of operations?

Q2. What plot is a comprehensive relative display of positions and tracks of friendly, enemy, and unidentified surface and subsurface targets?

STATUS BOARDS

Status boards provide a listing of current tactical information which, because of space limitations, cannot be presented on plots but must be available immediately for proper evaluations. The size, number, and purpose of status boards vary with different types of ships. Most status boards are edge-lighted and have a 36-inch-square writing area. The type of boards and the information to be plotted on them should be explained in the combat systems doctrine of each ship.

The following sections discuss some of the status boards used by ships of the fleet.

Tote Board

The tote board contains all of the amplifying information on every air contact plotted on the air summary plot. The tote board contains three sections—bogey, CAP, and other friendlies—as shown in figure 2-2.

Ideally, the tote board is located next to the air summary plot. The two boards together form the complete air summary display.

The tote board is maintained by one to four persons, depending on the type of ship and the situation.

Air Event Board

The air event board (figure 2-3) lists all the aircraft listed in the daily flight plan from the carriers. It also lists all scheduled flights from air bases in the area in which your ship is operating. Information recorded on the air event board includes the event number, amount and type of aircraft, call, side numbers, mission, launch/land time, and target. The board can be modified to include information such as IFF/SIF assignment, controlling ship, and radio channel.

Identification Status Board

If space permits, all ships will have an identification status board. This board lists the mode II personal identification (PIF) code assignments for every ship and aircraft expected to be encountered during a particular operating period. In addition, the board should list mission codes. Mission codes indicate the type of mission the aircraft are flying. For example, all CAP aircraft will squawk the same mission code; AEW aircraft will squawk a different code. The identification status board provides a convenient and ready reference for the mission codes currently in effect.

BOGEY	TN	CSE	SPD	ALT	COMP	TIME	WEAPONS ASSIGNED			REMARKS
							CAP	BIRD	GUN	
T4F2	0315	170	350	23	1	1723	✓			BADGER
T4F-3	0320	255	325	30	1	1725	✓			RAK-4

CAP						OTHER FRIENDLIES	
CALL	TN	ANG	STATE	STATION	TIME	TN/CALL	REMARKS
SB201/203	0275	24	160-4-0-2	270ZZ60	1715	0251	TANKER
GS110/107	0261	30	150-4-4-0	000ZZ-60	1715		

OS310203

Figure 2-2.—Example of a tote board.

CV/BASE	EVT	#/TYPE	CALL	SIDE #	MISSION	LAUNCH/LAND	TARGET	REMARKS
CONNIE	1A	2/F14	SB	201/203	CAP	1630/1830		
C.VINSON	1B	2/A7	HT	513/515	STK	1630/1830	4	
ENT	2A	1/KA3	BD	607	TKR	1630/2030		
CONNIE	1J	2/F14	SB	212/206	CAP	2115/2315		
ENT	2K	2/A6	TS	420/401	STK	2115/2315	2	

OS310204

Figure 2-3—Example of an air event board.

Discrete Identifier (DI) codes listed in OpOrders, messages, etc., are another means of identifying ships in the task organization and other shipping. These are not the same as the mode II codes previously mentioned. The DI codes are entered into the NTDS system for readout on link 11. Individual ships of the task organization can be identified easily. Other ships can be identified according to origin, type, etc., by the breakdown of the digits. For instance, the first digit may identify the country of origin, the second may indicate the type of ship, and so forth. Individual ship codes as well as the format for the other shipping should be displayed on the identification status board.

Voice Call Sign Board

The voice call sign board contains a listing of all voice calls of ships, commands, and task organizations. It may also include special call signs adapted for the particular exercise or tactical situation in which your ship may be engaged.

Communication Status Board

The communication status board indicates radio circuit assignments, frequencies, equipment allocation, radio remote station channelization, and use. It also may show additional remarks pertaining to the communications plan.

Equipment Status Board

All of the equipment in CIC should be listed on the equipment status board. Specifically, this list should include radars, IFF (transponder, interrogator, radar set control, coders/decoders), radar repeaters, associated NTDS equipment (computers, consoles, keysets, etc.), remote radio units, direction finders, and plotting equipment (DRT/DDRT). Two columns should be provided after the name of each piece of equipment. One column is for equipment that is operating; the other is for equipment that is out of service. A check mark in the appropriate column indicates the equipment status. For main radars, there should be a column for ring-time checks and readings. Also, there should be a column for the time the equipment went out or was taken down and one for the estimated time for it to be back in operation. A “Remarks” column should give the reason for equipment being down and include any other information important to restoring equipment to full operation.

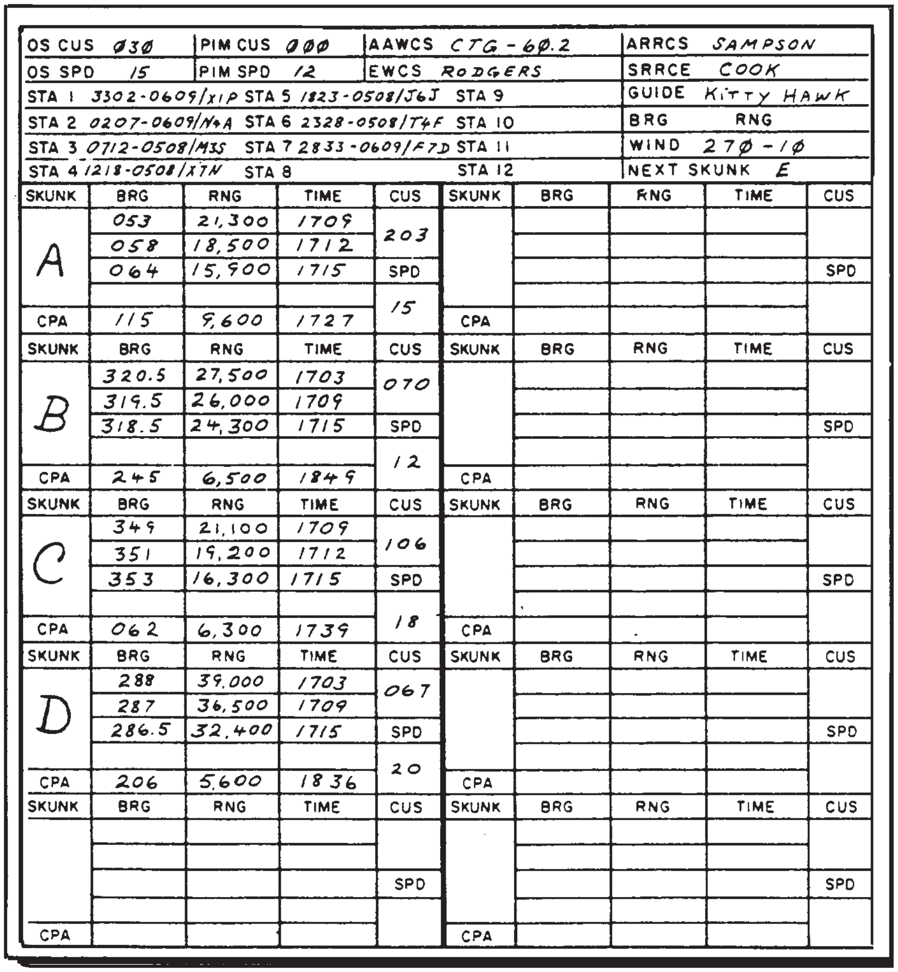
Surface Status Board

The surface status board displays a summary of surface data such as own ship and base course and speed, guard assignments, formation guide, screen stations, and wind direction and speed. Included also are the position, course, speed, closest point of approach (CPA), time of CPA, time of report, and any appropriate amplifying remarks on every surface contact. Figure 2-4 shows a recommended format for the surface status board. It may be modified to include other data, such as formation type and axis, zigzag plan in effect, replenishment, and amphibious data, depending on the mission of your ship.

Task Organization Status Board

The task organization status board displays the entire task organization structure in which your ship is operating. It identifies the ships assigned to task groups, units, and elements. It also identifies the commanders, the ship in which they are embarked, and the purpose of each task group, unit, and element.

On most ships, status board space is at a premium. For this reason, the task organization can be combined



OS310205

Figure 2-4.—Example of a surface status board.

with the voice call sign board or kept in a folder for easy reference by all CIC watch personnel.

ASW Flow Board

During ASW operations, you may be assigned as a recorder on the ASW air control net. Your job is to record on the ASW flow board all data passed from the aircraft to your controller. The flow board is a time base display pertaining to possible, probable, or certain submarine contacts, as well as to air, surface, and subsurface forces assigned to combat them. Information presented on the board includes contact classification codes, datum designation, method of establishing datum, the time of such designation, and detection and attack reports.

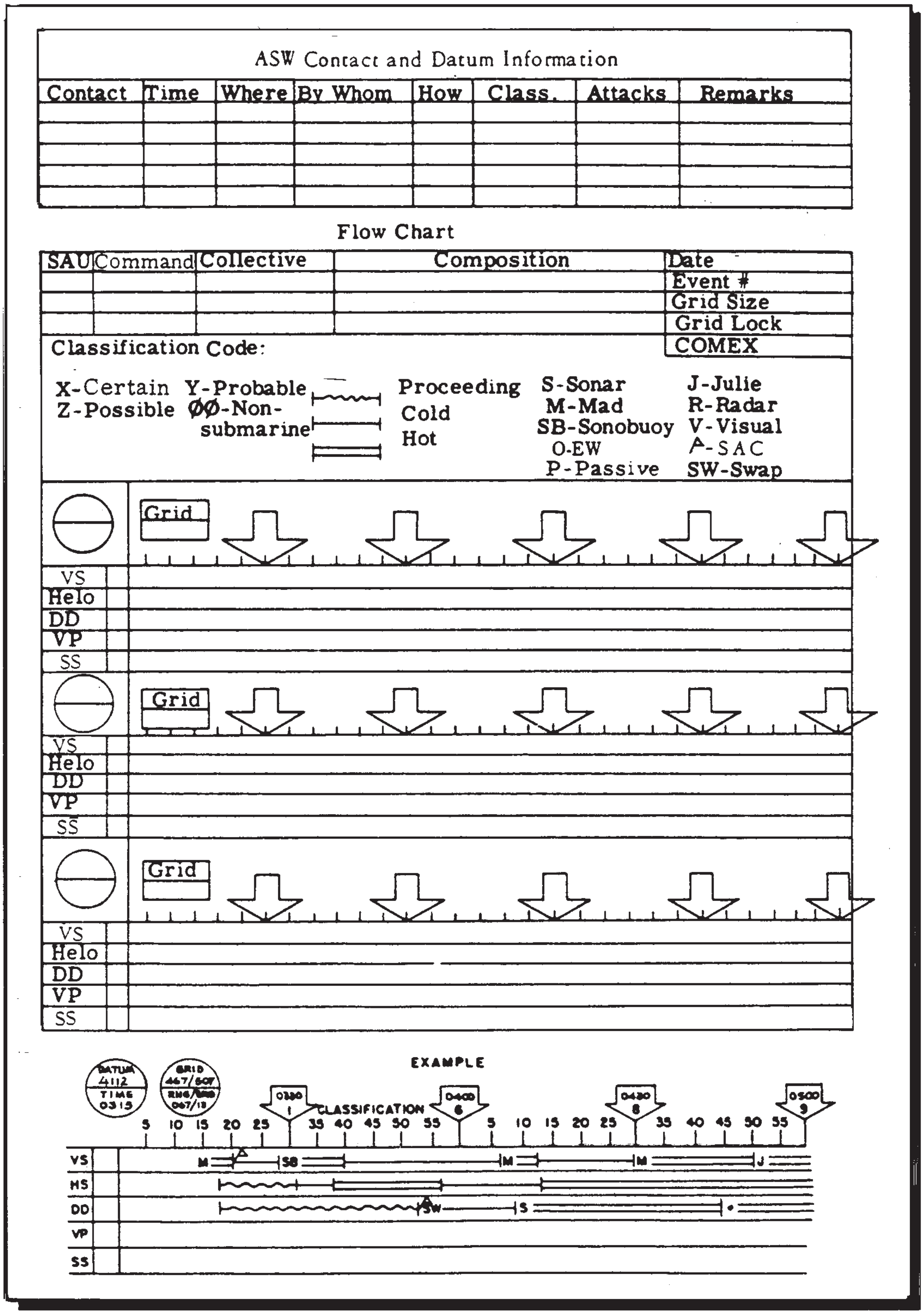
A typical ASW flow board is shown in figure 2-5. The information presented and the format of the board vary, depending on the ship's needs or type doctrine. From time to time, changes in aircraft, equipment, and weapons necessitate changes in the board. Figure 2-5, consequently, is presented only as a guide for making your own board.

Q3. *What status board contains information on every air contact plotted on the air summary plot?*

Q4. *What status board lists the day's flight plans?*

NAVAL TACTICAL DATA SYSTEM

The Naval Tactical Data System (NTDS) was designed to provide naval forces with increased combat direction capabilities. The average "conventional" CIC operation was both complicated and slow; and visual displays generated on plotting and status boards were never totally accurate. In general, they didn't show sufficient information pertinent to a given situation. The introduction of high-speed aircraft, long-range weapons, and complicated air-control tasks required vastly improved information-handling equipment. The NTDS satisfied that requirement.



2-5.—Example of an ASW flow board.

By providing the necessary electronic instrumentation for increased data gathering, display, and dissemination capabilities of ships and units, the Naval Tactical Data System improved fleet combat effectiveness. As a high-speed processing system, it furnishes to command vital information, already processed, to aid in more rapid and effective evaluation of each tactical situation.

An NTDS setup includes the following equipment in quantities dictated by the size and mission of the ship:

- One to four general-purpose digital computers
- Multipurpose consoles
- Data links.

Each of the general-purpose computers has a high-capacity memory, capable of storing about 1 million bits (binary digits) of tactical data and program instructions. Random and high-speed access to such data and instructions is possible.

The computer is the heart of the system. Its operational capabilities are determined by whatever program is stored in its memory. Programs are designed to cover a number of operational environments that may exist in CIC and are stored permanently on magnetic tapes. The computer (and the system) can be configured and reconfigured rapidly to meet the operational requirements as they change, with little or no loss of time.

The computer performs the following functions:

(1) accomplishes all necessary correlations, computations, updating, amplification, and other processing;

(2) displays and disseminates the tactical situation in real time;

(3) provides logical recommendations and alternatives to aid human decision makers in evaluating threats and assigning weapons; and

(4) automates the designation of targets to missile batteries and the control of interceptors.

The human operators perform their functions at consoles in CIC and in the flag commander's plotting room. With minor exceptions, these consoles are multipurpose units, in that the operators can switch them to any of several functions. A console, for example, may be used for detecting, tracking, and identifying targets; for entering electronic warfare information, and for other data-gathering functions. Likewise, it may be used for weapons coordination, intercept control, air coordination, surface operations, and other evaluating and decision-making functions on both ship and task force levels. This built-in redundancy provides a high degree of system flexibility, versatility, reliability, and maintainability. A system may include from 10 to 30 such consoles, depending on the type of ship.

Q5. What was NTDS designed to provide?

LARGE SCREEN DISPLAYS (LSDs)

On AEGIS cruisers and destroyers, the new aircraft carriers, and the new large deck amphibious ships, the conventional vertical plots (air summary and surface summary) have been replaced with large-screen displays or LDSs. The LSD is a 42-inch by 42-inch projection of what is shown on the AN/UYK-21 TDS consoles. The presentation consists of yellow characters on a field of blue, displayed at a resolution of 525, 729, or 1075 lines per frame. On a *Ticondaroga* class cruiser there are four LSDs; an *Arleigh Burke* destroyer has two. The carriers and large deck amphibious ships will have several LSDs throughout CIC.

AUTOMATED STATUS BOARDS (ASTABS)

Since the vertical plot is gone, it only makes since to do away with the other status boards in CIC. Automated status boards or ASTABS have replaced many of the status boards we discussed at the beginning of this chapter. An ASTAB is nothing more than a CRT that displays information provided by the AN/UYQ-21 TDS consoles. These CRTs display the information that was previously written on conventional status boards (Task Organization Status Board, Air Events Board, Voice Call Sign Board, etc.). The information displayed on the ASTABs is entered from keyboard in the bull nose of the TDS console. For more information on the operation of LSDs and ASTABs, refer to your ship's TDS operation manuals.

ANSWERS TO CHAPTER QUESTIONS

A1. Strategic plot.

A2. Surface summary plot.

A3. Tote board.

A4. Air event board.

A5. Increased combat direction capabilities to naval forces.

CHAPTER 3

INTERNAL COMMUNICATIONS

LEARNING OBJECTIVES

After you finish this chapter, you should be able to do the folloiwng:

1. Identify the types of shipboard internal communication systems and state their uses.
2. Recognize sound-powered phone nomenclature
3. Identify sound-powered phone equipment and describes its operation
4. Demonstrate proper sound-powered phone operating procedures.

INTRODUCTION

This chapter gives you an overall picture of CIC's internal communication systems, methods, and procedures.

Whenever we communicate, we make every effort is to ensure the speed, accuracy, reliability, and security of the communication. Bear in mind that although accuracy, reliability, and security are essential, those efforts will be wasted unless the communication is made in ample time to be completely effective.

The success of all CIC operations depends on teamwork. What is teamwork? Teamwork is the coordinated actions of two or more members of a team. How do we achieve this coordinated action? By exchanging ideas, information, and orders, we let others know what we are doing or are planning to do. Without communications, the CIC team is not really a team. It is merely a group of people doing different jobs, with little chance for actually accomplishing the mission. Therefore, every member of the CIC team must become an expert in voice communications.

TYPES OF INTERNAL COMMUNICATIONS

Several types of shipboard internal communications are used in CIC. They are (1) voice tubes, (2) ship's service telephones, (3) messengers, (4) pneumatic tubes, (5) multi-channel (MC) systems, and (6) Inter Voice Communication System (IVCS), (7) CIC Communications group, (8) sound-powered telephone systems. Not every ship's CIC has all of these means of communication. The larger ships do, but the smaller ones may have only a few of them. As our discussion progresses, we will examine each type of internal communications.

VOICE TUBES

Voice tubes provide an important means of internal communications, although they are normally used only as a standby measure. This system is merely a network of metal tubes designed to carry the sound of the voice from one station to another. The major value of this system is that it is practically immune to mechanical failure. Consequently, it can be relied upon when accidents or damage disrupts other systems.

SHIP'S SERVICE TELEPHONES

Although the ship's service telephones are not part of the battle communication system, they can prove invaluable if the regular systems fail. They are standard telephones powered by the ship's generators and are normally used in carrying out the administrative routine aboard ship. Two features expedite the telephone-calling process: the executive cut-in telephone and the hunt-the-not-busy-line feature.

Executive cut-in telephones, clearly marked, are for emergency calls and for the use of persons in authority. Operationally, these telephones are the same as a standard telephone but are limited in number and can be used to call a station that is in use. Instead of a busy signal being returned, the cut-in phone breaks into the circuit. The caller then can interrupt the conversation in progress to deliver an important message.

The hunt-the-not-busy-line feature can be used when a call is made to an area that has a group of consecutively numbered telephone stations. After the lowest numbered station has been dialed, the switchboard connects the calling station to the lowest numbered idle telephone. When all the circuits of the group called are in use, a busy signal is returned as with a standard telephone.

MESSENGERS

Ships today still use the oldest method of communication—the messenger. Although messengers are a reliable means of communication, they are not as fast as the other methods. You will be called on many times during your naval career to use your knowledge of the ship by serving as a messenger.

PNEUMATIC TUBES

Pneumatic tubes are for relaying written messages between communication stations in some ships. This system has the advantage of routing a message quickly. Two disadvantages are that it needs ship's power for compressed air and that it is good for written messages only.

MULTI-CHANNEL (MC) SYSTEMS

Multi-channel (MC) systems transmit orders and information between stations within the ship, by means of direct, amplified voice communications. There are two types of MC equipment—one type is used in intercommunication (intercom) systems; the other type is used in shipboard announcing systems. Each type has distinguishing features, which we discuss below.

Intercommunicating (Intercom) Units

Intercommunication (intercom) systems allow two-way transmission of orders and information between stations (in the same space or in different spaces). Each intercom unit contains its own amplifier.

There are several basic types of intercom units in use throughout the Navy, with certain variations to the basic types (fig. 3-1). These types differ mainly in physical appearance and in the materials used in their construction. Regardless of their appearance and construction, all intercom units have the same electrical characteristics. This allows units of different construction and from different manufacturers to be used in one common system. The components consist essentially of a reproducer, controls, and an amplifier.

The **reproducer** serves both as a microphone and as a loudspeaker. An incoming call can be heard through the loudspeaker because the sound is amplified by the amplifier of the calling unit.

The **controls** consist of the talk switch, a pushbutton assembly, a busy light, a call light, a volume control, and a dimmer control.

When the talk switch is depressed, the reproducer functions as a microphone and the output of the amplifier is electrically connected to the reproducer of the called station. When the switch is released, the reproducer functions as a loudspeaker. The talk switch is spring loaded and returns to the listen or standby position when released.

A handset can be used with the intercommunicating unit in place of the reproducer. The operation is the same as that of the reproducer except that the pushbutton in the handset is used as a talk switch in place of the regular talk switch on the front

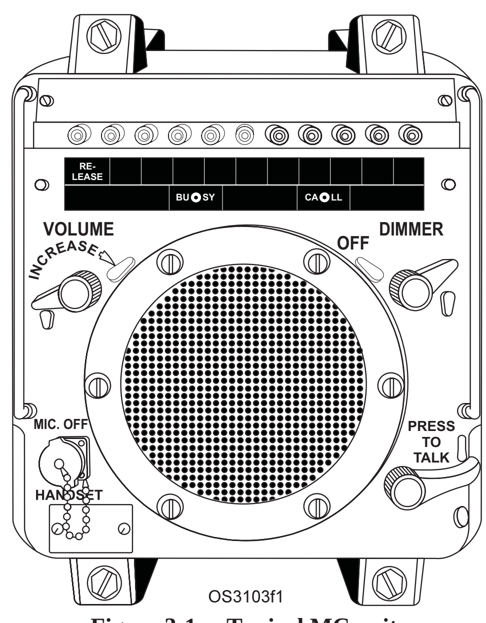


Figure 3-1.—Typical MC unit.

panel. Incoming calls can be heard simultaneously in the handset and in the reproducer. The volume control controls the level of the incoming call to the reproducer only.

A portable microphone can also be used with the equipment. The operation is the same as that of the reproducer except that the pushbutton on the microphone is used as a talk switch instead of the regular talk switch on the equipment.

The station selector buttons are located at the top of the front panel. The locations or designations of the various units in the system are engraved in the station designation plate below the associated selector buttons. When a station selector button is depressed, it will lock in the operative position until the release pushbutton is depressed to return it to the non-operative position.

The "busy" lamp is lighted when a station button is depressed to call another station and the station being called is busy. Do not leave a station selector button depressed when the "busy" lamp is lighted. Depress the release pushbutton and call later.

The dimmer control controls all illumination of the unit. The "busy" and "call" lights are off when the control knob is in the extreme counterclockwise position and are fully lighted for all other positions as the knob is turned clockwise. The station designation lights are lighted for all positions of the control knob and the illumination increases as the knob is turned clockwise.

The volume control varies the volume of incoming transmissions. This control has no effect on the volume of the outgoing sound from the unit. Thus, the volume of each unit in the system can be adjusted to the desired level.

To call a particular station, depress the station selector button of the desired station, depress the "talk" switch, and speak directly into the grille. Release the "talk" switch to listen. When you complete your conversation, depress the "release" pushbutton to return the station selector switch to the non-operative position.

To accept a call from another station, listen to the incoming call through the loudspeaker. Do not operate any of the station selector switches. Depress the "talk" switch to reply to the incoming call. The "call" light illuminates to indicate that the station is being called by another station.

Shipboard Announcing (MC) Systems

Shipboard announcing systems (also called central amplifier systems), are designed to broadcast orders or information to a large number of stations simultaneously. In each of these systems, a central amplifier is used, hence, the system affords only one-way communication.

The following are a few of the MC systems that you may see and use (some are not located in CIC).

General (1MC) — The general announcing system is a one-way system found on practically all ships—large or small. The system's transmitter is not located in CIC, but you may have occasion to use it while standing in-port quarterdeck watches. It is used for passing general orders and administrative information. Transmissions can be made from key stations—bridge, quarterdeck, and damage control stations—to all or selected groups of stations or compartments within the ship and to all topside areas. The 1MC also provides a means for transmitting emergency alarms throughout the ship.

Ready Room (19MC) — The 19MC provides two-way communications for stations dealing with air operations on aircraft carriers. Stations on the circuit include CIC, ready rooms, flight deck control, hangar deck control station, air intelligence, and the wardroom.

Combat Information (20MC) — The 20MC is used primarily to pass combat intelligence from each main plotting group in CIC to a variety of users. These include primary and secondary conning stations, captain's tactical plot, open bridge, main battery control stations, anti-air warfare stations, main battery director stations, main and secondary battery plotting rooms, flag bridge, flag command and plotting stations, missile control stations, and electronic warfare (EW) stations.

Captain's Command (21MC) — The 21MC provides two-way transmission of ship control orders and information among key stations. Key stations include primary and secondary conning stations, signal bridge, main battery control station, air warfare station, radio central, damage control station, main engine control, CIC, primary flight control station, and the captain's tactical plot. CIC uses the 21MC to send initial contact reports and any emergency information to the bridge. The signal bridge frequently transmits information it receives from flaghoist to the bridge and CIC at the same time.

Radio Room (22MC) — The 22MC is used to pass information and orders concerning radio facilities, as well as data, between radio rooms and certain other radio operating stations. In CIC, you may use the 22MC to call radio and request a frequency setup on a transmitter or to check a radio receiver that may be drifting out of tune.

Flag Command (24MC) — The 24MC system provides two-way transmission of flag orders and information between selected stations, such as flag bridge, signal bridge, flag plot, flag radio, radio central, open bridge, combat information center, and captain's tactical plot.

Sonar Information (29MC) — The 29MC system provides one-way communication from sonar operators to the captain's tactical plot, open bridge, pilothouse, CIC, underwater battery plot, and the ASW attack station.

CIC Coordination (42MC) — The 42MC is usually found in CICs in larger ships, especially those having a modular CIC. Such an arrangement provides communications at any time between key personnel within CIC.

INTERIOR VOICE COMMUNICATION SYSTEM (IVCS)

IVCS is a computer–controlled voice system that serves as the ship's internal telephone system and replaces the majority of the circuits traditionally associated with sound-powered telephones. IVCS has predefined networks, such as the Lookout net with jack boxes at all lookout watch stations and the pilothouse. IVCS nets are listed in Table 3-1.

In addition to jack boxes, IVCS provides telephone terminals throughout the ship. The majority of these are standard dial terminals. Some terminals have additional features such as multi-line, remote speakers, or hands-free operation. Besides serving as a telephone, each IVCS terminal can access all IVCS nets.

CIC INTERCOMMUNICATIONS GROUP

The CIC communications system provides CIC console allows operators to call other console operators, to sign on to CIC nets, to talk on secure and plain R/T circuits, and, through the IVCS interface, to call any telephone on the ship or to access IVCS nets. Each console in CIC and sonar control, and the one console on the bridge, has a communications unit. In addition to the communications units at each console, remote units are located in CIC for watch stations not associated with a standard console, such as electronic warfare (EW) and TOMAHAWK. CIC nets are listed in Table 3-2.

Table 3-1.—Common IVCS Nets

CHANNEL	PURPOSE
11	Helicopter and Boat Fuel Control
12	Helicopter Control
22	Navigation Coordination
25	Combat System Officer of the Watch (CSOOW) Coordination
26	Electronic Support Supervisor Coordination
29	Underwater Supervisor Coordination
51	Captain's Battle Net
52	Lookout Reporting
53	Maneuvering Control
54	Navigation Service
55	Visual Signals
56	Docking
60	Gun Coordination and Service
62	Forward VLS Strikedown
63	Aft VLS Strikedown
65	Ordnance Supervisor Coordination
66	Fire Control Supervisor Coordination
68	Light Machine Gun Coordination
80	Damage and Stability Control
81	Repair 2
82	Repair 3
83	Engineering
84	Fuel Control
85	Electrical
86	Repair 5
88	Vehicular Control Helicopter Transfer (VCHT)
90	Firefighting Equipment
91	Emergency Reporting

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SOUND-POWERED TELEPHONE SYSTEM

The commanding officer can fight the ship most effectively when he is provided with adequate and accurate evaluated information. This information must be passed over sound-powered (S/P) telephone circuits from damage control (DC) central, engineering spaces, weapons control, after steering, combat information center (CIC), radio central, signal bridge, lookouts, and other stations in the ship. A good phone talker is vital to the ship and plays an important part in the ship's overall performance.

Supervisory personnel and S/P telephone talkers can exchange information adequately and accurately

Table 3-2.—CIC Nets

CHANNEL	PURPOSE
1	Command Casualty Net
2	Antiair Warfare (AAW) Casualty Net
3	Antisurface Warfare (ASUW) Casualty Net
4	ASW Casualty Net
5	Gunfire Control System (GFCS) Casualty Net
6-9	Unassigned
10	Surface/Subsurface Tracking (SST) Coordination
11	ASW Coordination
12	AAW Coordination
13	ASUW Coordination
14	Tactical Information
15	Command
16	Force Coordination
17	Electronic Warfare (EW)
18	GFCS
19	Digital Dead Reckoning Tracer (DDRT) Plotting
20	Sonar Coordination
21-49	Unassigned

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and in the most timely and efficient manner only when they know and abide by the rules for talkers. Talkers must use standard phrases and common terminology and know and practice proper care of their S/P telephone. You should already have a basic knowledge about sound-powered telephones. However, because S/P telephones are considered the "workhorses" of shipboard internal communications systems and since their use in CIC is quite extensive, we need to study them further.

Advantages of S/P Telephones

Several advantages are afforded by sound-powered telephone equipment for internal communications. A few of them are as follows:

It is simple to operate.

- The equipment is rugged, when given reasonable care.
- Talkers are not distracted by external noise, because their ears are isolated by the telephone's ear pads.
- Security or privacy of communications is superior to that provided by MC equipment.
- Transmissions do not contribute to station noise levels.
- The talker is mobile within the limitations set by the length of the cord and, except while transmitting, is free to perform other tasks, such as those required of a radar operator or plotter in CIC.
- The earphones may be used for emergency transmissions if the microphone becomes defective, and vice versa.
- The system does not require an external source of power for operation.

Circuit Nomenclature

Each sound-powered telephone circuit is designed for a specific purpose. The groups linked by a sound-powered circuit may include the bridge, the underway and docking stations, and the damage control teams. Each circuit is identified, according to its use, by a letter and number code, as explained below.

J—The first letter of a primary sound-powered-circuit designation is *J*. It indicates that the circuit is a sound-powered communication link.

J***S***—The second letter identifies the general purpose of the circuit.

22JS—Numerals preceding the letters indicate the specific purpose of the circuit. In this example, the designation means that the circuit is an air search radar information circuit.

22JS***1***—Numerals after the letters indicate a particular station in the circuit—for example, the air summary plotter.

X22JS1—The letter *X* indicates that the circuit is in the auxiliary S/P telephone system.

Circuit Requirements in CIC

The number of sound-powered circuits required in CIC depends on the type of ship. Normally there are more circuits in larger ships than in smaller ones. All types of ships, however, have certain minimum circuit requirements. These needs include separate circuits as follows:

- Between each search radar and the plotters for that radar
- Between the EW room and other CIC stations
- Between the visual lookout station, CIC, and other stations

- Between radio central (communications) and CIC and other stations
- Between CIC, bridge, and other conning stations
- For direct communications between CIC and flag plot (on flagships)
- Between CIC and each weapons control station, including sonar in sonar-equipped ships
- For aircraft information in carriers

Large ships, in which there are many sound-powered telephone circuits, use a more elaborate setup. The number of phones manned depends on what the ship is doing. More circuits are manned at general quarters than during normal steaming watches. Table 3-3 shows the common S/P circuits used in CIC.

Sound-Powered Telephone Equipment

There are so many varieties of sound-powered telephone equipment that it would serve no practical purpose in this text to discuss all of them. We can, however, discuss a few units, and by studying them you should gain a better understanding of the sound-powered system.

DRUM-TYPE SELECTOR SWITCH.—The drum-type selector switch (fig. 3-2) makes it possible to cut a single jack into any one of a number of circuits by turning the switch to the desired circuit marked on the face of the dial. Because of the construction of the switch, only one circuit can be connected at a time.

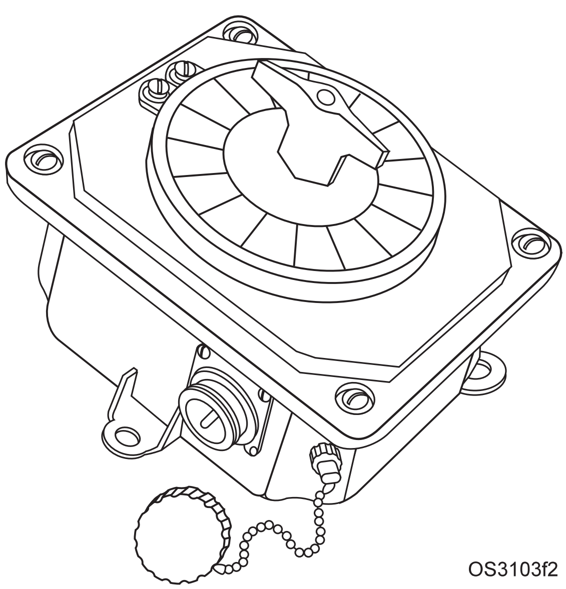

Figure 3-2.—Drum-type selector switch.

CALL SIGNAL STATION BOX.— The call signal box contains a handset phone (see figure 3-3). The purpose of this circuit is to provide communication between stations that normally do not need to exchange information continually. Two distinct circuits compose the call bell system. The first is the S/P circuit to which all the handsets are connected. The second is the call circuit.

On the call circuit, the operator turns the selector switch to the desired position (this switch is usually numbered 1 through 16), turns the magneto hand crank, and listens on the handset until someone answers the call. This circuit does not have a bell like a standard telephone; instead, it makes a growling noise, and is sometimes referred to as the *growler*. Although this circuit is not in constant use, it is a good idea to listen in on the circuit before turning the magneto, to avoid having two conversations on the same S/P circuit. A nameplate just above the selector dial lists the stations on the circuit, identified by the appropriate station number.

PLOTTERS' TRANSFER SWITCH-BOARD.—Most ships have a plotters' transfer switchboard installed in CIC. This switchboard (fig. 3-4) allows the CIC S/P circuits to be patched to various stations. For convenience, S/P telephone jack stations are located throughout CIC and are numbered JS1, JS2, JS3, etc. (These jack station numbers are shown on the left side of the switchboard in figure 3-4.)

Through use of the plotters' transfer switchboard, the plotter who is plugged in to JS7, for instance, can talk on any of the S/P circuits that are wired to the switchboard. (The S/P circuits are shown across the top of the switchboard in figure 3-4.) You can patch the plotter who is plugged in to JS7 into the 21JS circuit

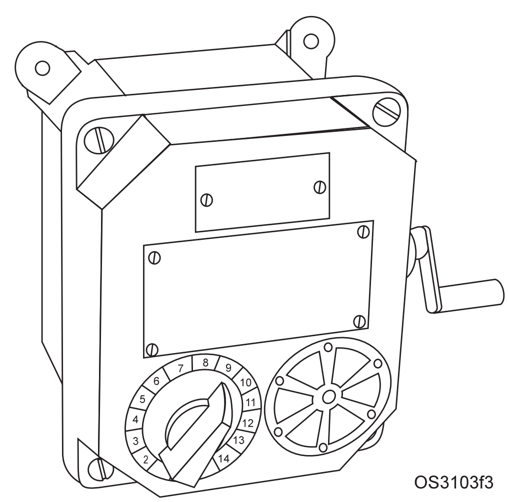

Figure 3-3.—Call signal station box.

Table 3-3.—Common sound-powered Phone Circuits

CIRCUIT	PURPOSE	INFORMATION PASSED	STATIONS ON CIRCUIT	WHEN MANNED IN CIC
JA	Captain's Battle Circuit	Orders From Command To All Stations. Recommendations To Command	Bridge/Pilot House*, CIC, And Weapons Stations.	At All Times
JC	Weapons Control	Gun/Missile Control Orders And Target Designation/Acquisition Information	Bridge*, CIC, Weapons Control, Weapons Plot, All Fire Control, Gun And Missile Stations.	During GQ, AAW, And Radar Assisted Piloting
JL	Lookouts	Visual Sighting Information.	Bridge*/Pilot House, CIC, And Lookout Stations.	At All Times
JX	Radio And Signals Circuit	Visual And Radio Tactical Signals And Important Communications Traffic.	Bridge*, Signal Bridge, CIC, And Radio Central.	During GQ
1JS (1)	CIC Information	Raw And Evaluated CIC Information To Ship Control Stations.	Bridge*/Pilot House And CIC.	At All Times
1JV	Maneuvering And Docking Circuit	Engine Orders; Anchor, Line Handling, And Steering Control Information.	Bridge*, CIC, Main Control, After Steering, Secondary Conn, Forecastle, Midships, And Fantail.	During Special Sea And Anchor Detail.
1JW	Ship Control Bearing Circuit	Visual Navigation Information, Depth Readings, And Exchange Of Navigational Fix Information.	Navigator*, Bearing Takers, Depth Sounder, And CIC.	During Radar Assisted Piloting.
X6J	Electronic Service Circuit	Electronic Casualty And Repair Information.	Electronic Casualty Control*, CIC, And All Electronic Equipment Spaces.	During GQ
21JS	Surface Search Radar	Surface Contact Information	RCO*, Surface-Search Radar Operator, And All Surface Plotters.	At All Times
22JS	Long-Range Air-Search Radar	Long-Range Air Contact Information.	RCO*, Air-Search Operator And All Air Plotters.	At All Times
24JS	Range-Height Radar	Altitude Information.	RCO*, Height-Finding Radar, And All Height Plotters.	At All Times
61JS	Sonar Information	All Sonar Contact Information.	Bridge*, Sonar, And All CIC ASW Plotters.	During ASW Operations
81JS	EW Information	Intercepted Signal Characteristics And Evaluations.	RCO*, EW Equipment Operators, And Plotters.	At All Times

*Control Station

Notes:
1. On ASW ships the 1JS is used only as a command circuit during ASW operation.
2. The JA, JL, 1JV, and/or 1JS circuits may be crossed, in any combination, during normal steaming in order to decrease the number of personnel required to man these circuits.
3. The 21JS, 22JS, and 24JS circuits are used for communications within CIC only.
4. The information listed above may vary on different ships according to the individual command requirements.

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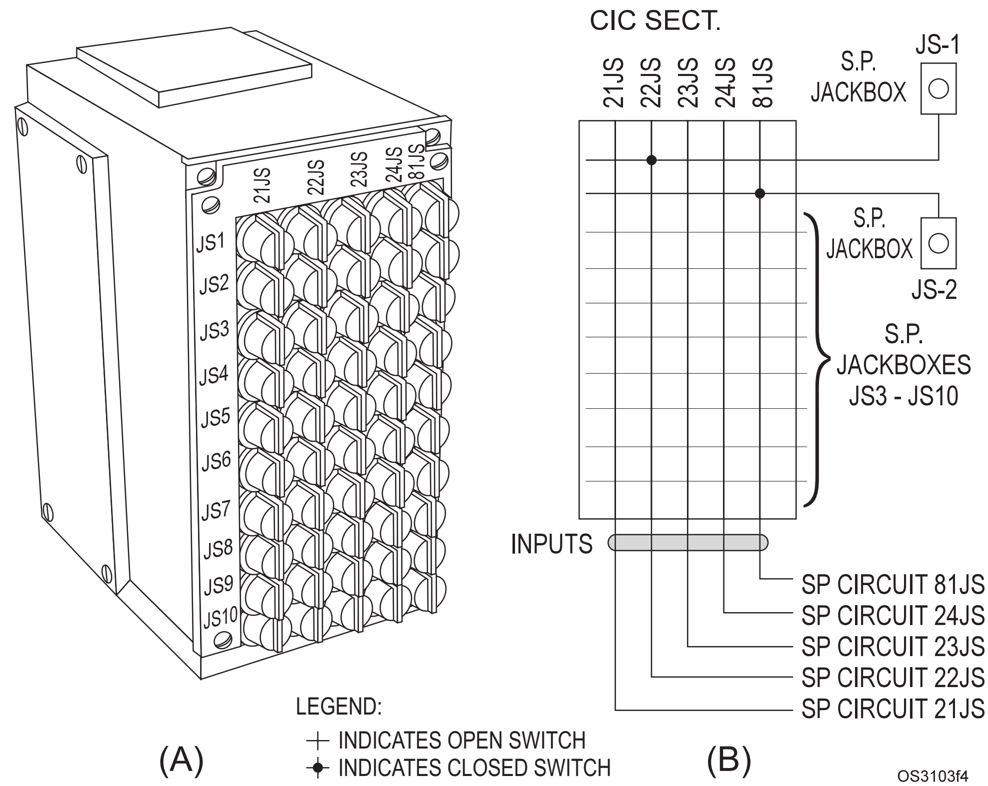


Figure 3-4.—Plotters' transfer switchboard.

as follows: Locate JS7 on the left side and 21JS on the top of the switchboard. Move horizontally to the right from JS7 to the switch that is located vertically under 21JS. Turn this switch clockwise 90° to patch the 21JS circuit into JS7.

More than one circuit may be patched to the same jack station. However, when this is done, the circuits in question are crossed, and every station on the two circuits will be in communication with every other station. Sometimes it is desirable to cross circuits, but carelessness in switching circuits can result in unnecessary cross patches. For this reason, only experienced personnel should make all changes to the plotters' transfer switchboard.

Care of Telephone Equipment

Sound-powered telephones are of sturdy construction. If handled with reasonable care, they should require little attention. Nevertheless, they are fine instruments, perform an important function, and should be treated accordingly. Observe the following precautions.

- Avoid pulling on the electrical connections, and never use the cables for carrying or handling the equipment.
- Remember that the length of the cord is limited. If you attempt to walk any farther than the cord permits, the cord may be pulled loose from the jack plug.
- Unauthorized persons should not disassemble S/P telephones or tamper with them in any way.
- Do not insert any object through the protective screen. The diaphragm may become damaged.
- When secured, telephones should be made up and stowed on hooks or in the stowage boxes provided. Never leave the telephone adrift or exposed to the weather.
- Never remove a pair of telephones from a stowage box that does not belong to your station. Should general quarters be sounded, the individual who normally used those phones would not be able to man the station, and the safety of your ship could be at stake.
- When you wear a pair of phones, always try to keep the excess cord out of the way of people passing by. If you leave the cord in the way, someone may trip on it and sustain injury or cause damage.
- Do not leave inoperative telephones on station. Telephones that are out of order should be tagged and turned in at once to the IC room or telephone repair locker. They should then be

replaced by sets that are in good operating condition.

Q1. What are the eight common types of internal communications used in CIC?

Q2. List four advantages of sound-powered telephones.

S/P TELEPHONE AND IVCS PROCEDURES

The purpose of having standard sound-powered-telephone and IVCS procedures is to provide uniformity of expression, enabling messages to be understood more clearly over the phones. In every CIC in the fleet, day in and day out, Operations Specialists deal over and over with the same type of information—bearings, ranges, speed, distances, and other tactical data. CIC personnel can handle information with speed, accuracy, and reliability when they have a system that is simple, easily understood, and readily usable. They can then place every transmission into a brief and clear form that will be understood instantly and is ready for use when received.

A system that satisfies these requirements is the standard sound-powered-telephone procedure and phraseology. The system is simple. Speed is not achieved by transmitting rapidly and biting off words or running them together. Speed is gained by using standard procedure and terminology with every transmission.

GENERAL RULES

The following is a list of some general rules for sound-powered-phone talkers.

1. Be alert. Pay attention to what is said over the phones. If possible, maintain a written log of the activities of other stations on the circuit. Pay attention to the officer or petty officer in charge of the station.
2. Repeat or relay all messages <u>word for word</u>. DO <u>NOT</u> REPHRASE ANY MESSAGE. Changing a single word may can change the meaning of the entire message.
3. Do not engage in idle conversation on the phone. Keep your mind on your assigned duty.
4. Speak into the transmitter in a loud, clear tone; do not shout or whisper. Shouting results in mushy, slurred noises. A whisper cannot be heard. Speak distinctly. Pronounce every syllable. Restrict your dialect or accent.
5. When using a headset, hold the button down when talking, but do not touch it when listening. When using a handset, hold the button down both to speak and listen.
6. Hold the headset transmitter about 1/2 inch from your mouth when talking.
7. Do not use alphabetic letters as references. This practice can lead to confusion and errors that may result in a considerable loss of time and can prevent needed action that might have been taken had the message been received correctly. Use words in the phonetic alphabet, such as ALFA, GOLF, PAPA, and XRAY.
8. To be an important member of any team, you must become familiar with all the duties of the CIC team.
9. As an OS, strive to be the best talkers on the circuit.

BASIC MESSAGE FORMAT

The basic format for transmitting a message by sound-powered telephone consists of the standard shipboard names for the station called and the station calling, followed by the text (what is to be said) in clear, concise language. In the example below, Combat is passing information about a surface contact to the bridge.

Message from Combat: "Bridge, Combat. Surface contact—TOO SIX ZE-RO—TWEN-TY TOW-ZAND

Response from the bridge: "Bridge—Aye, Aye "

NOTE

Do not call a station and wait for word to go ahead. Every time you have information to transmit, call the station(s) concerned, identify your station, and send the message. If you do not get a response, repeat your message.

S/P PHRASEOLOGY

If all called stations could receive and entirely understand every transmission on the first transmission, there would be no need for anything more than the procedure mentioned above. Unfortunately, not all transmissions are received

perfectly. Operators sometimes make errors during transmissions; communication is difficult at times. To help prevent errors, standardized words or phrases come in handy. Using them helps eliminate transmission errors and misunderstandings. Some of the common terms and their meaning follow.

1. SILENCE ON THE LINE — Use this term only in emergencies. When a transmission in progress on the circuit is interrupted by a message of extreme importance, the person on the circuit must cease talking to permit the cut-in to send the important message.

2. AYE AYE — Use this standard response to all transmissions you receive completely. It means "I have received all of your transmission and will deliver it exactly as received."

   Never use this response if you are uncertain that you received all of the transmission. Also, do NOT use it simply as an affirmative answer to a question. After you give an AYE AYE to a message, either use the information the message contains if you are the "action" addressee or pass the message on to the person responsible for taking action.

3. SAY AGAIN — With this term, you signify that you did not receive the message. The proper response to the term by the sender is a complete retransmission of the message.

4. CHANGING PHONES; BACK ON THE LINE — Use the term CHANGING PHONES when you remove the telephone headset to give it to another talker. CHANGING PHONES signifies that your station will temporarily be unable to receive messages. The new talker should report BACK ON THE LINE when he or she is ready to resume normal operations. This process should take very little time to complete.

5. CORRECTION — The word CORRECTION preceded and followed by a pause during a transmission indicates that the sender made an error and is correcting it. Examples of errors are a mispronounced word, an omitted word or phrase in the text, or the incorrect information. If you make an error, make the correction to the message clearly and distinctly. To correct an error, pause, speak the word CORRECTION, pause, retransmit the last word or phrase that you transmitted correctly, transmit the corrected word or phrase, and then transmit the rest of the message. This procedure is particularly important when you are transmitting a series of numerals.

6. REPEAT BACK — When you want to be sure the receiving talker has understood your message correctly, you may ask him or her to repeat it back to you by saying "Repeat back."

7. THAT IS CORRECT (or WRONG) — If you direct another talker to REPEAT BACK a message that you send, you must acknowledge the repeat with either THAT IS CORRECT (or WRONG) —do not use the phrase AYE AYE.

   a. Say "THAT IS CORRECT" if the receiver repeats the message correctly.

   b. Say "WRONG" if the receiver repeats the message incorrectly. Then give the correction.

8. BELAY MY LAST — Sometimes, as you are transmitting a message, but before you complete the transmission, you may realize that you made an error that you can correct only by stating the message over. Or, you may realize that you shouldn't have sent the message. In such instances, use the phrase BELAY MY LAST. Do not use this phrase to cancel a message that you have completely transmitted and had receipted.

9. WAIT — Use the word WAIT when you need to make a pause of short duration (several seconds) during a transmission. You can also use it when someone requests information that you do not have immediately available.

NUMERAL PRONUNCIATION

Although it is impossible to completely standardize the phraseology used in the text of a sound-powered-telephone message, numerals can be and are standardized. Since numerals are the Operations Specialist's "chief stock in trade" and because most of the information supplied by CIC is expressed in numerical form (bearings, ranges, speeds, distances, time, and so on), you should learn from the beginning to treat numerals with the care they deserve.

Personnel in CIC cannot afford to make errors in the information they handle, because in many instances it is vital to ship control. Numerical errors concerning enemy forces, when passed on to the command, could prove disastrous in wartime. Even in peacetime, numerical errors on tactical maneuvering or navigational data may cause a disaster.

For an example of how numerals can be misunderstood, say the following numbers aloud: 7, 11, 17, 70 (seven, eleven, seventeen, seventy). Notice that the sounds are similar. If they are slurred or are pronounced indistinctly, there is room for error. A carelessly pronounced “seventeen” may sound like “seventy”. If range (in miles) is the subject, mistaking “seventeen” for “seventy” will introduce an error of 53 miles. You can avoid making such an error by following the well-established communications rules listed below.

Basic Digits

Ten basic digits make up the numerical system. Each digit must be pronounced distinctly so that it will be understood. Learn to pronounce them as they are written in the accompanying list.

Number	Spoken as	Number	Spoken as
0	ZE-RO	5	FIFE
1	WUN	6	SIX
2	TOO	7	SEV-EN
3	TREE	8	AIT
4	FOW-ER	9	NIN-ER

Rules For Pronouncing Numerals

If the basic digits were the only consideration in using numerals, there would be little problem. Unfortunately, numerals may form an indefinite number of combinations, and the combinations may be spoken in several different ways.

The following rules apply to the pronunciation and expression of numerals. Situations may arise, however, in which these rules are inapplicable. In these cases, try the pronunciation and expression that best fit the situation.

1. Always speak the numeral 0 (written Ø) as ZE-RO, never as *oh*. This rule applies to ranges as well as to bearings.

2. Speak decimal points as DAY SEE MAL.

3. For ranges and distances given in units other than “miles”, transmit the numbers digit by digit except for multiples of hundreds and thousands. Say them as such. Some examples are:

Number	Spoken as
44	FOW-ER FOW-ER
9Ø	NIN-ER ZE-RO
136	WUN TREE SIX
5ØØ	FIFE HUN-DRED
14ØØ	WUN FOW-ER HUN-DRED
1478	WUN FOW-ER SEV-EN AIT
7ØØØ	SEV-EN TOW-ZAND
16ØØØ	WUN SIX TOW-SAND
165ØØ	WUN SIX FIFE HUN-DRED
2ØØØØ	TOO ZE-RO TOW-ZAND
812681	AIT WUN TOO SIX AIT WUN

4. Ranges and distances given in mile units, and speed, are transmitted as the integral cardinal number. Some examples are:

Number	Spoken as
1Ø	TEN
13	THUR-TEEN
25	TWEN-TY FIFE
5Ø	FIF-TY
11Ø	WUN HUN-DRED TEN
3ØØ	TREE HUN-DRED

5. Altitude of raid aircraft is always expressed in feet. Altitude may be spoken either in exact integral cardinal numbers or in multiples of thousands (angels), using the integral cardinal number. Some examples are:

Altitude	Spoken as
7ØØ	700“Altitude SEV-EN HUN-DRED” or “Angels DAY-SEE-MAL SEVEN”
11ØØ	1100“Altitude ELEV-EN HUN-DRED” or “Angels WUN point WUN”
55ØØ	“Altitude FIF-TY FIFE HUN-DRED” or “Angels FIFE point FIFE”

1Ø5ØØ	"Altitude TEN TOW-ZAND FIFE HUN-DRED" or "Angels TEN day-see-mal FIFE"
2ØØØØ	"Altitude TWEN-TY TOW-ZAND" or "Angels TWEN-TY"

NOTE

The brevity code word *angels* pertains to the height of friendly aircraft only. The word *altitude* pertains to bogey height, in exact integral cardinal numbers.

6. Target altitude information relayed to weapons support is expressed in feet. Exact multiples of hundreds and thousands are spoken as such. Some examples are:

Number	Spoken as
1ØØ	WUN HUN-DRED
1ØØØ	WUN TOW-ZAND
11ØØ	WUN TOW-ZAND WUN HUN-DRED

7. Courses, bearings, and angles other than position angles are given in three digits and are transmitted digit by digit. Some examples are:

Number	Spoken as
Ø9Ø	ZE-RO NIN-ER ZE-RO
18Ø	WUN AIT ZE-RO
295	TOO NIN-ER FIFE

Position angles, always less than 90º, may be expressed in one or two digits and are pronounced as the integral cardinal number. When so transmitted, the phrase *position angle* always precedes the numerals. Some examples are:

Number	Spoken as
5	POSITION ANGLE FIFE
1	POSITION ANGLE TEN
15	POSITION ANGLE FIF-TEEN
27	POSITION ANGLE TWEN-TY SEV-EN

8. Time is always spoken digit by digit and preceded by the word "time".
TIME: 1215–WUN TOO WUN FIFE

Q3. When is it appropriate to use the phrase "silence on the line" on a sound-powered telephone circuit?

Q4. What sound-powered telephone circuit is used to pass sonar contact information?

ANSWERS TO CHAPTER QUESTIONS

A1. (1) voice tubes, (2) ship's service telephones, (3) messengers, (4) television, (5) pneumatic tubes, (6) target designation equipment, (7) multi-channel (MC) systems, and (8) Inter Voice Communication System (IVCS), (9) CIC Communications group, (10) sound-powered telephones

A2. Simple to operate; rugged, when given reasonable care; talkers are not distracted by external noise; security or privacy of communications is superior to that provided by MC equipment; transmissions do not contribute to station noise levels; the talker is mobile and, except while transmitting, can perform other tasks; the earphones may be used for emergency transmissions if the microphone becomes defective, and vice versa; the system does not require an external source of power for operation.

A3. Only in an emergency.

A4. 61JS.

CHAPTER 4

LOGS, RECORDS, AND PUBLICATIONS

LEARNING OBJECTIVES

After you finish this chapter, you should be able to do the folloiwng:

1. Identify logs used in CIC and the information they contain.

2. Identify the records maintained in CIC.

3. Discuss the information contained in OPPLANS and OPORDERS.

4. Identify the mission-related publications found in CIC and the information they contain and explain the requirements and procedures for stowing and handling the publications.

5. Discuss classified material destruction procedures and the reports required after classified documents are destroyed.

INTRODUCTION

The efficient administration and operation of CIC requires that various records and logs be maintained and that reports be made. To ensure that these requirements are fulfilled, Operations Specialists must know the essentials for maintaining the required CIC logs, records, files, and publications. They also must be familiar with the many publications kept in CIC, such as instructions, notices, OpOrders, and OpPlans; and the proper accountability procedures for maintaining them. OSs must also be familiar with emergency destruction procedures for all the classified material in CIC.

This chapter describes the basic logs, records, and other documents found in CIC and explains how they must be maintained and destroyed

LOGS

Information received in CIC is recorded in notebooks or standard ledgers. These notebooks are called *logs* and are required to provide a permanent, continuous record of the ship's operations. Generally, information contained in CIC logs is divided into three categories: (1) personnel, (2) equipment, and (3) operation.

Regardless of the log's category or type, its purpose is to provide a complete and accurate record of performance and operations for later evaluation. It is also used in preparing reports and for verifying that certain evolutions were accomplished or that certain events occurred. Consider the following examples:

- When a navigation accident occurs, CIC logs may be used to reconstruct the surrounding situation.

- A training log can be invaluable in showing the amount and kind of training CIC personnel have received.

- A supply log can be a great help in keeping track of inventory and in preparing supply requisitions.

The CIC officer has overall responsibility for all logs in CIC, but delegates (but does not relinquish) this responsibility to CIC watch officers. Specific entries, however, are made by Operations Specialists assigned as log keepers. For example, the CIC watch officer is responsible for proper maintenance of radiotelephone logs, but a radiotelephone operator actually makes entries in the log. As an Operations Specialist, you may be assigned duty as log keeper for *any* log kept in CIC.

SHIP OPERATIONAL DATA FORMS

Ship operational data forms, the OPNAV 3l00-3360 series, provide a standard format for recording operational and exercise data. You can find instructions for using each on the reverse side of the form or on the first page of the log.

The following is a partial list of surface ship operational data forms:

Title	OPNAV Form No.
General log	3100/2
Ships Position Log	3100/3
Surface Radar Contact Log	3100/5
ESM Tactical Log	3100/7
Sonar Watch and Contact Log	3360/90

Spaces or boxes on the forms are numbered to facilitate computer entries. Figure 4-1 shows headers found on typical operational data forms. Except for ship type, header entries should be placed against the right-hand side of every box, with zeros entered in any unused spaces.

Boxes 1 and 22 are data card identifiers and are preprinted on all forms.

Box 2 is the originator level and is preprinted on all forms.

Boxes 3 through 7 are for ship type and hull number. Enter the first two letters of the ship type in spaces 3 and 4, and the remaining letters in the next two shaded unnumbered spaces. If the hull number consists of four digits, enter the first digit in the shaded unnumbered space.

Boxes 10 and 11 are for serializing the sheets. Number each sheet consecutively each day, beginning with 01; enter the time as 0001.

Box 12 is for the year. Enter the last digit of the current calendar year.

Boxes 13 and 14 are for the number of the current month.

Box 15 is for the time zone. Enter the letter designation for the time zone you have been directed to use for normal data entries.

Boxes 16 and 17 are for the day of the month.

Box 78 is for the security classification. TS—Top Secret;S—Secret;C—Confidential; U—Unclassified.

Box 79 is for special security handling. Leave this blank unless you receive special instructions.

Now that you are familiar with log headers, we will discuss some actual logs. The ones we discuss constitute the minimum logs recommended for adequate records in any CIC. You may find additional logs used aboard your ship, since the number and types of logs vary from ship to ship.

Surface Radar Contact Log

The Surface Radar Contact Log, OPNAV Form 3100/5, is used for recording radar contacts. When you

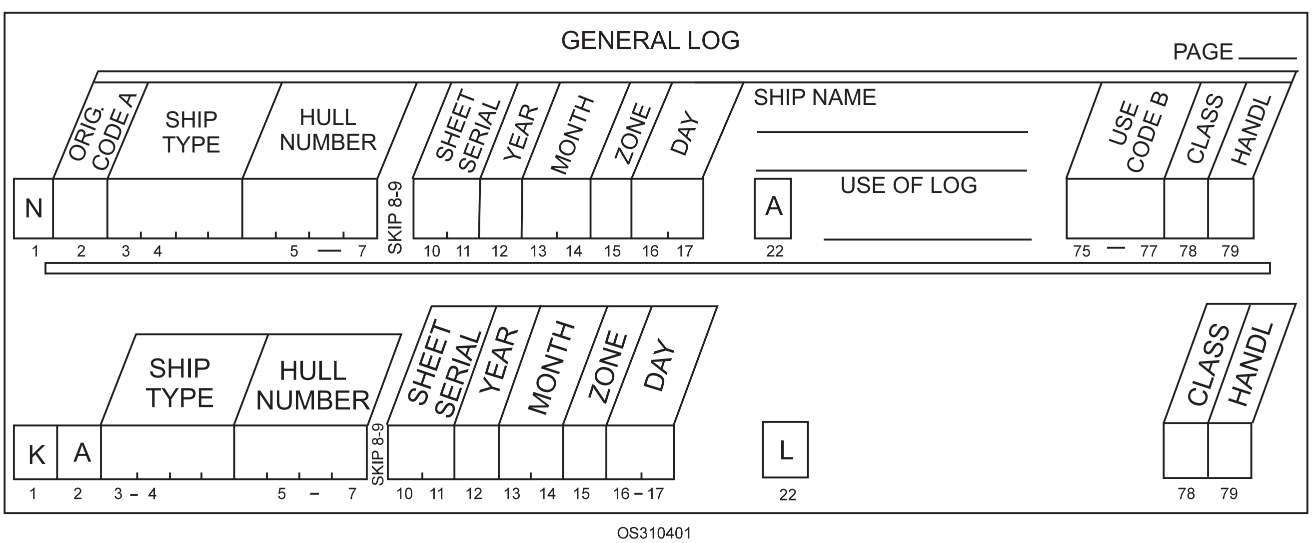


Figure 4-1.—Operational data form headers.

pick up a contact, log its range, bearing, and time of detection. Enter the contact's course, speed, and CPA when they are determined. Enter the time when the contact is put on watch or scrubbed. At the time a contact fades from the scope, enter its range and bearing. Figure 4-2 is an example of the Surface Radar Contact Log. Instructions for filling out the log are on the reverse side of each sheet (fig. 4-3).

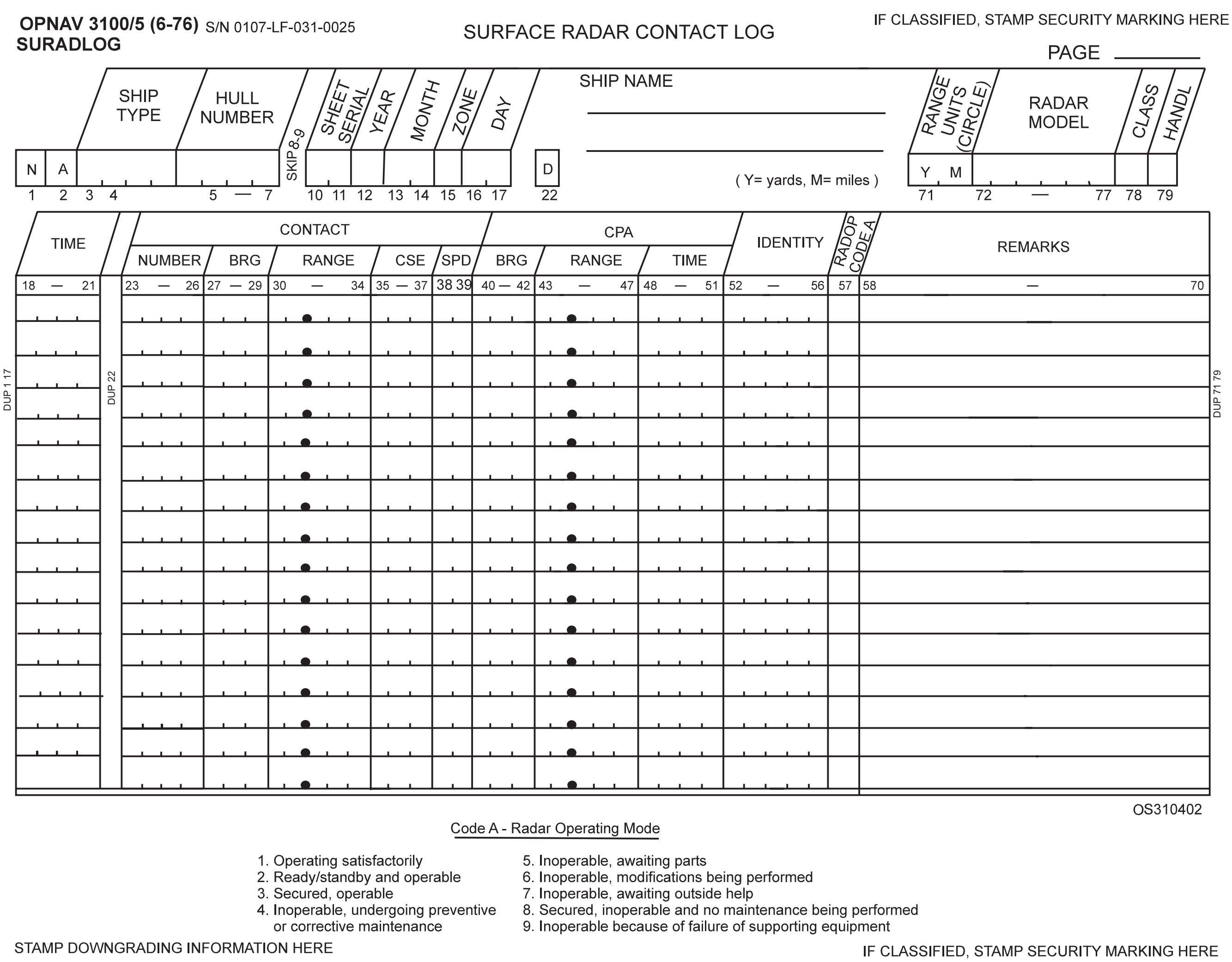
CIC Watch Log

The CIC watch log should be a complete and accurate chronological account of both routine and unusual events pertaining to a CIC watch. Normally, the CIC watch supervisor keeps this log, but in some instances, you may be assigned to keep the log. Log entries may be either printed or written, but must be legible.

Most CIC logs are maintained on a General Log, OPNAV Form 3100/2 (fig. 4-4). These log forms are loose-leaf, and each page must be serially numbered when the log is opened for use. Figure 4-5 gives instructions for specific use of the General Log.

In addition to its use as a CIC log, the General Log may be used to record information when no other operational data form applies.

CIC watch log entries are similar to ship's deck log entries and should be made in black ballpoint pen ink. Once you have made a log entry, do not erase it. If you need to correct an entry and are authorized to make the correction, draw a single line through the original entry so that it remains legible. Then insert the correct entry so that it is clear and legible and initial the correction in the margin of the page. For all logs, additions or changes to log entries must be made personally by the individual who signs the log for the watch.


OPNAV 3100/5 (6-76) S/N 0107-LF-031-0025
SURADLOG
SURFACE RADAR CONTACT LOG
IF CLASSIFIED, STAMP SECURITY MARKING HERE
PAGE ______

SHIP TYPE	HULL NUMBER	SKIP 8-9	SHEET SERIAL	YEAR	MONTH	ZONE	DAY	SHIP NAME	RANGE UNITS (CIRCLE)	RADAR MODEL	CLASS	HANDL
N A								D (Y= yards, M= miles)	Y M			
1 2 3 4	5 — 7		10 11	12	13 14	15	16 17	22	71	72 — 77	78	79

TIME		CONTACT NUMBER	CONTACT BRG	CONTACT RANGE	CONTACT CSE	CONTACT SPD	CPA BRG	CPA RANGE	CPA TIME	IDENTITY	RADOP CODE A	REMARKS
18 — 21		23 — 26	27 — 29	30 — 34	35 — 37	38 39	40 — 42	43 — 47	48 — 51	52 — 56	57	58 — 70

DUP 1 17 DUP 22 DUP 71 79

OS310402

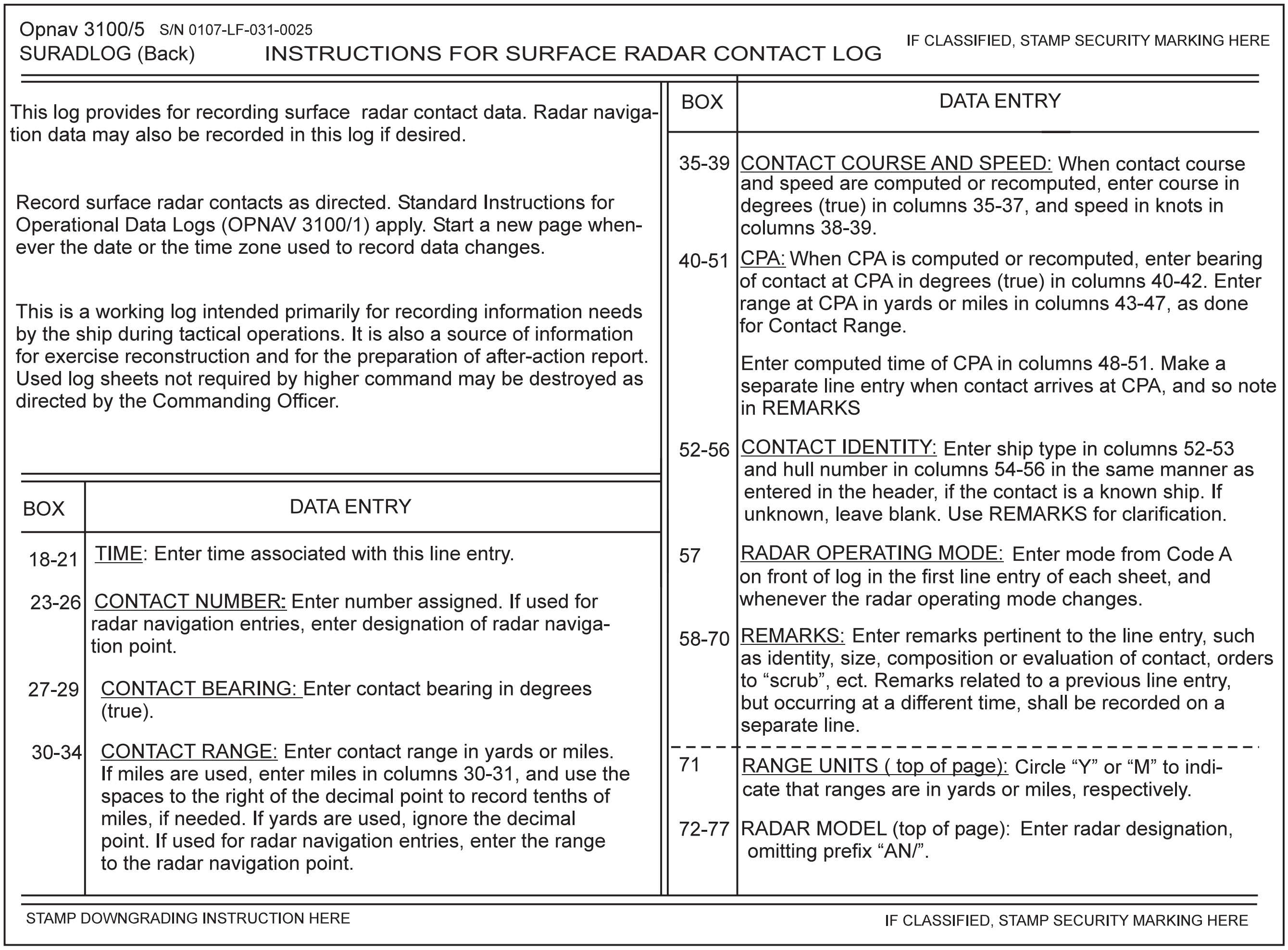
Code A - Radar Operating Mode

1. Operating satisfactorily
2. Ready/standby and operable
3. Secured, operable
4. Inoperable, undergoing preventive or corrective maintenance
5. Inoperable, awaiting parts
6. Inoperable, modifications being performed
7. Inoperable, awaiting outside help
8. Secured, inoperable and no maintenance being performed
9. Inoperable because of failure of supporting equipment

STAMP DOWNGRADING INFORMATION HERE

IF CLASSIFIED, STAMP SECURITY MARKING HERE

Figure 4-2.—Surface Radar Contact Log.



Opnav 3100/5 S/N 0107-LF-031-0025
SURADLOG (Back) INSTRUCTIONS FOR SURFACE RADAR CONTACT LOG

IF CLASSIFIED, STAMP SECURITY MARKING HERE

This log provides for recording surface radar contact data. Radar navigation data may also be recorded in this log if desired.

Record surface radar contacts as directed. Standard Instructions for Operational Data Logs (OPNAV 3100/1) apply. Start a new page whenever the date or the time zone used to record data changes.

This is a working log intended primarily for recording information needs by the ship during tactical operations. It is also a source of information for exercise reconstruction and for the preparation of after-action report. Used log sheets not required by higher command may be destroyed as directed by the Commanding Officer.

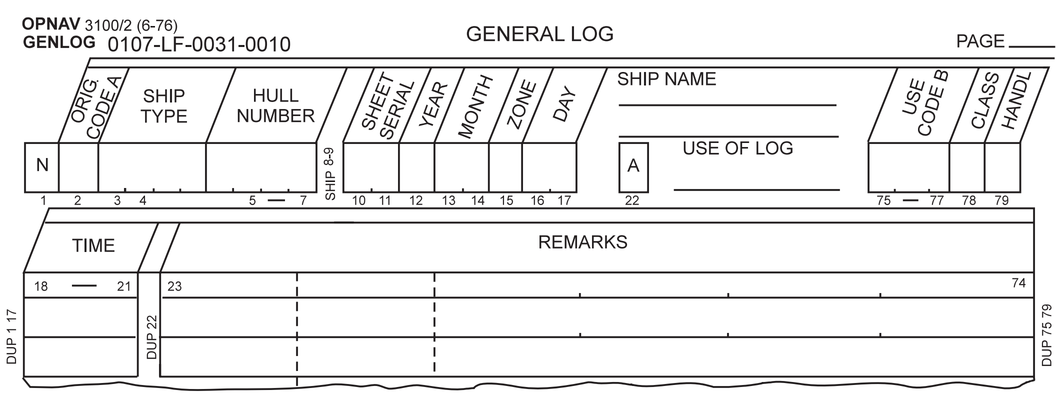
BOX	DATA ENTRY
18-21	TIME: Enter time associated with this line entry.
23-26	CONTACT NUMBER: Enter number assigned. If used for radar navigation entries, enter designation of radar navigation point.
27-29	CONTACT BEARING: Enter contact bearing in degrees (true).
30-34	CONTACT RANGE: Enter contact range in yards or miles. If miles are used, enter miles in columns 30-31, and use the spaces to the right of the decimal point to record tenths of miles, if needed. If yards are used, ignore the decimal point. If used for radar navigation entries, enter the range to the radar navigation point.
35-39	CONTACT COURSE AND SPEED: When contact course and speed are computed or recomputed, enter course in degrees (true) in columns 35-37, and speed in knots in columns 38-39.
40-51	CPA: When CPA is computed or recomputed, enter bearing of contact at CPA in degrees (true) in columns 40-42. Enter range at CPA in yards or miles in columns 43-47, as done for Contact Range. Enter computed time of CPA in columns 48-51. Make a separate line entry when contact arrives at CPA, and so note in REMARKS
52-56	CONTACT IDENTITY: Enter ship type in columns 52-53 and hull number in columns 54-56 in the same manner as entered in the header, if the contact is a known ship. If unknown, leave blank. Use REMARKS for clarification.
57	RADAR OPERATING MODE: Enter mode from Code A on front of log in the first line entry of each sheet, and whenever the radar operating mode changes.
58-70	REMARKS: Enter remarks pertinent to the line entry, such as identity, size, composition or evaluation of contact, orders to "scrub", ect. Remarks related to a previous line entry, but occurring at a different time, shall be recorded on a separate line.
71	RANGE UNITS (top of page): Circle "Y" or "M" to indicate that ranges are in yards or miles, respectively.
72-77	RADAR MODEL (top of page): Enter radar designation, omitting prefix "AN/".

STAMP DOWNGRADING INSTRUCTION HERE

IF CLASSIFIED, STAMP SECURITY MARKING HERE

OS310403

Figure 4-3.—Reverse of the Surface Radar Contact Log.



OS310404

Figure 4-4.—General Log.

INSTRUCTIONS FOR GENERAL LOG

This log provides a convenient format for recording chronological information or remarks, as required or desired, and may be used for the following:

1. CIC watch log.
2. Command narrative or command remarks.
3. Voice radio, sound-powered phone, or underwater telephone log.
4. Radar navigation, NGFS, or boat control log.
5. Any chronological record not otherwise provided for elsewhere.

Use a separate sheet for each originator level as defined in Code A, and for each use as defined in Code B. Start a new sheet at the beginning of each day, and whenever the time zones used to record data changes.

For each use of the log, enter the use, ship, and applicable time period on the cover. After entries are made in the log, stamp the appropriate security classification onto the cover if the entries are classified. Standard Instructions for Operational Data Logs (OPNAV 3100/1) apply.

This is a working log intended primarily for recording information needed by the ship during tactical operations. Its is also a source of information for exercise reconstruction and for the preparation of after-action reports. If desired, sheets may be removed for convenience if the ship name and use are shown on each sheet. Ship name and use need not be filled in as long as the sheets are bound.

BOX	DATA ENTRY
2	ORIGINATOR LEVEL: Enter from Code A.
10-11	SHEET SERIAL: Start with "0" at the beginning of each day if the sheet is removed from the logbook. Otherwise, it may be left blank.
18-21	TIME: Enter time associated with this entry on the first line of entry. Leave blank for subsequent lines of a single entry. Leave blank for remarks not related to time.
23-24	(Not shown) To be used for line serial numbers if sheet is keypunched.
25-74	REMARKS: Enter the narrative, remarks or message associated with this entry; use more than one line if needed. Vertical dashed lines are provided as column marking for specific data entries; when using the columns for a specific purpose, enter the purpose at the top as shown in the examples below.
75-77	USE: Enter from Code B.

Code A-Originator Level

A	Ship personnel
E	OPCON
F	Task Unit Commander afloat
G	Task Group Commander afloat
H	Sector Commander
K	Force/Fleet Commander
M	CINC
N	CNO

Code B-Use

CIC	CIC watch log.
COM	Command narrative or remarks.
TAC	TF/TG tactical log.
REP	TF/TG reporting log.
VOI	Other voice radio log. (Write circuit name in first entry.)
SON	1JS/61JS monitor log.
PHO	Other sound-powered phone log. (Write circuit name in the first entry of remarks.)
UOC	Underwater telephone log.
NTD	NTDS Link 14 usage report.
RNV	Radar navigation, NGFS, boat control navigational fix log.
OTH	Other. (Explain in the first entry of remarks.)

INSTRUCTIONS FOR SPECIFIC USES

CIC WATCH LOG: Use for a chronological record of events as directed by operational commanders, ignoring the dashed vertical lines. Entries should include:

An initial daily entry showing the overall situation, such as:

1. Tactical data, e.g., Formation, station, PIM.
2. Status of equipment in CIC.
3. Guard assignments and EMCON conditions in effect.

Significant events as they occur, such as:

1. Changes to initial entries describes above.
2. Important reports transmitted or orders received
3. Courses and speeds recommended to conn.
4. Changes to status of equipment.
5. Other occurrences of interest to the CIC watch.

OS310405

Figure 4-5.—Instructions for General Log.

The log entries can be divided into three groups: initial entry, chronological entries, and final entry. As we discuss each group, we will assume that you are keeping the log.

INITIAL ENTRY—.At the top of the "Remarks" section on a new page, record the time as 0000 (local). Record the CIC watch officer's name at the top left of the "Remarks" section and your name and watch section at the top right. Next, list all equipment in use, whether it is in a standby status or out of commission. Then list tactical data, such as formation, formation axis, ship's station assignment, ship's course and speed, special guard assignments, and other unusual or special data reported by the off-going watch supervisor. Be sure an oncoming supervisor reads the captain's night order book and notes any unusual or important comments that it contains.

If you are beginning the mid-watch, be sure the initial entry fully describes any activities in which the ship is engaged. This will provide valuable reference and historical material. An entry on the 0000 to 0400 watch might read as follows:

> 0004—Steaming in company with Task Group 17.1, composed of USS *Abraham Lincoln* (CVN-72), USS *Antietam* (CG-54),USS *Gettysburg* (CG-64), USS *Hopper* (DDG-70), USS *John S McCain* (DDG-56), and USS *Kauffman* (FFG-59). OTC is CTG 17.1 in USS *Antietam* (CG-54). En route from Pearl Harbor to Subic Bay, P.I. *Abraham Lincoln* is the guide bearing 090°, range 7000 yards. Condition of readiness 3 and material condition YOKE are set. Ship darkened except for running lights.

NOTE

> All bearings are true unless indicated otherwise. On successive watches, the first entry should read "Steaming as before."

CHRONOLOGICAL ENTRIES—. During a CIC watch, record all events of special interest. These include contacts, bearings, ranges, courses, speeds, CPAs, fades (unless a separate contact log is kept); directions to CAP to intercept bogeys; contacts with enemy forces; and equipment casualties or changes of status. Events of special interest also include courses, speeds, and other tactical changes; the substance of important reports transmitted or orders received; and other occurrences of interest that normally are not recorded in other CIC logs.

Generally, abbreviations in the CIC watch log are limited to those usually accepted throughout the naval service. The following is a partial listing of commonly used abbreviations. Refer to Instructions for Keeping Ship's Deck Log, OPNAVINST 3100.7, for a complete listing of abbreviations and log-keeping guidelines.

C/C	Changed course
C/S	Changed speed
CPA	Closest point of approach
OCE	Officer conducting exercise
OTC	Officer in tactical command
SOP	Senior officer present
SOPA	Senior officer present afloat
Commands	COMCARGRU 16; CINCPACFLT; DESRON 13; COMDESRON 13, etc.

The following sample entries show typical formats that you will find in CIC watch logs. Your entries should have similar formats, although any entry is acceptable as long as it is complete, accurate, clear, and in standard naval phraseology.

CIC log entries concerning air operations aboard a carrier:

1000	Flight quarters.
1005	Commenced launching aircraft for (carrier qualification) (refresher operations) (group tactics), etc; base course ________. Speed _______.
1020	C/C______, C/S______.
1025	Completed launching aircraft, having launched 40 aircraft.
1035	Commenced recovering aircraft; base course ______. Speed ______.
1035	Commenced maneuvering, on various courses (and speeds) while recovering (launching) aircraft (while conducting task group (force) flight operations).
1055	Completed recovering aircraft, having recovered 40 aircraft.
1143	Man overboard: one of the plane handlers fell overboard on the port side—latitude 36°50'N, longitude 74°31'W.

1144 USS Cook (FF-1083) and helicopter commenced search for victim.

1146 Victim recovered by helicopter and delivered (on board) USS *Nimitz* (CVN-68).

1215 Secured from flight quarters.

NOTE

During flight operations, log the base course and speed. Cover minor changes in course and speed by a statement such as "Maneuvering on various courses…etc."

CIC log entries made on a destroyer:

2100 Maneuvering on various courses to take plane guard station No. ______ on ______, lighting measure ______ in effect.

2100 On station.

2115 Commenced flight operations.

2210 F-14 aircraft crashed into sea off starboard bow; maneuvering to recover pilot.

2214 Recovered pilot.

CIC log entries concerning drills and exercises aboard any ship:

1000 Exercised at general drills. (for NBC attack drills):

1140 Atomic attack imminent; set condition ______.

1500 (Simulated) Atomic (underwater) (surface) (air) burst; bearing ______ range ______ yards; maneuvering to avoid base surge and fallout.

1530 Rejoined formation and took station ______ in formation ______; (axis, course, speed, etc.).

Fueling entries:

1100 Formed fueling formation______.

1100 Departed station and maneuvered to standby station astern of USNS *Henry J Kaiser* (TAO 187).

Formation entries:

0700 Maneuvering to take station ______ in formation ______; axis ______ course ______, speed ______. Guide is USS *Hue City* (CG-66) in station ______.

0800 Rotated formation axis to ______ .

0900 Formation changed from 40Z to 51V. New course and axis ______, speed ______ knots. Formation guide is USS *John C. Stennis* (CVN-74).

Officer in Tactical Command entry:

NOTE

Log all shifts of tactical command. When the OTC (Officer-in-Tactical Command)is the commanding officer of your vessel, use the following terminology: "OTC is commanding officer, USS *Blue Ridge* (LCC-19)." In every instance give the command title of the OTC, not his name and rank. State the vessel on which the OTC is embarked, such as:

0900 COMCARGRU 4, embarked in USS *Nimitz* (CVN-68), assumed OTC.

Rendezvous entries:

0800 *USS Paul Hamilton* (DDG 60) made rendezvous with this vessel (the formation) and took designated station (took station in the screen) (took plane guard station).

2200 Made rendezvous with TG 19.9 and took designated station number ______ in formation 40R, with guide in USS *Ogden* (LPD 5) bearing 095º distance 2400 yards, formation course ______, formation speed ______, axis ______ . OTC is COMCARGRU 4 in USS *Nimitz* (CVn-68)

Tactical exercise entry:

1000 Commenced division tactical exercises. Steering various courses and speeds (in Area HOTEL) (conforming to maneuvers signaled by COMDESRON 12) (on signals from COMDESRON 12).

Zigzagging entry:

1300 Commenced zigzagging in accordance with Plan No.______ base course ______.

1500 Ceased zigzagging and set course ______.

Navigational entry:

1600 Anchored in Area South HOTEL, Berth 44, Hampton Roads, Virginia, on the following bearings: Fort Wool 040, Middle Ground Light 217, Sewell's Point 072. Ships present: ______. SOPA COMDESRON 12 in USS *Jacinto* (CG-56).

Contact entries:

1621 Skunk 090º; 28,900 yards. Designated Skunk Alfa.

1629 Skunk Alfa (bearing) ______ (range) ______ on course ______ speed ______ knots. CPA ______, distance ______ miles.

1636 Skunk Alfa identified as USS *Spruance* (DD-963) by lookouts.

1715 Sonar contact 172º, 2500 yards.

1717 Contacts classified as possible submarine. Commenced attack (tracking) (investigating).

1721 Contact regained bearing 020º, range ______. Oil slick reported sighted by lookouts on that bearing and range. Commenced reattack.

FINAL ENTRY—.In the final entry for your CIC watch, include data of value to the oncoming watch and anything needed for a permanent record. Have the CIC watch supervisor sign the log. Then have the offgoing CIC watch officer inspect and sign the log.

Captain's Night Order Book

The captain's night order book is the captain's instructions to the watch. Although this record may actually be addressed to the officer of the deck, CIC personnel must also know its contents.

Standing night orders usually are posted inside the front cover of the night order book. Each day, on a separate page, the captain inserts a description of the general situation at the end of the day and any special orders (called current orders) that apply to the succeeding watches.

The OOD, JOOD, and CIC watch officer, and frequently the CIC watch supervisor, are required to initial current night orders to signify that they have read and understood them.

Radiotelephone Logs

Radiotelephone logs are logs that CIC maintains as directed by current operation orders and instructions. The TG Tactical/Warning net log and the TG Reporting net log are among the most important radiotelephone logs. All messages transmitted on the TG Tactical/Warning net must be recorded verbatim. Standard abbreviations, tape recorders, and modified shorthand codes are useful in copying nets.

Other nets for which logs are maintained as the occasion arises include the anti-air warfare coordination net and the AW weapons coordination net.

A separate log must be kept for each radiotelephone net; instructions are placed on the fly sheet of each log.

When a watch is set on a circuit, the date and the name of the circuit log keeper must be logged. Any time a log keeper is relieved or closes a net, he or she must sign the log. In all instances, the name or signature of the log keeper must be legible, so there will be no confusion over the identity of the log keeper.

The log must also include the following additional data:

1. The time the monitoring station was opened and closed
2. Any cause(s) of delay on the net or circuit
3. All adjustments and changes of frequency
4. All unusual occurrences, procedures, and security violations

Although voice transmissions are spoken slowly and clearly to make sure a message gets through, it may be difficult for log keepers to copy accurately, particularly if they are slow writers. A number of abbreviations (besides pro-signs) have been adopted to enable shortcuts in copying. The following is a list of common abbreviations. The left column contains

words heard on a circuit; corresponding shortcuts in writing a message are in the right column.

Words Heard	Abbreviation
This is	DE
Message for you	M4U
Acknowledge	Ack
Break	$\overline{\text{BT}}$
Roger (Message received)	R
Wilco (will comply with the order received)	Wilco
Course	Cus
Corpen	Corp
Speed	Spd
Position	Posit
Starboard	Stbd
Distance	Dist
Bearing	Bng
Range	Rng
Emergency	Emerg
Affirmative	Afirm
Negative	Negat
Stand by	Stdby
Say again (I say again)	$\overline{\text{IMI}}$
Execute (Execute to follow)	$\overline{\text{IX}}$
Immediate execute	Immediate IX
Time of execution	TOX
Time of delivery	TOD

To avoid any possibility of confusing a zero with the capital letter O, zero is distinguished by a slant line through it (Ø); the capital letter Z is written with a small bar (Ƶ) to distinguish it from the numeral 2.

Radar Navigation Log

A radar navigation log, sometimes called a navigational fix log, is necessary for all operations requiring CIC assistance in navigation. It usually is kept in a standard ledger-type notebook. This log is used whenever radar navigation is conducted, such as when the ship is entering port, leaving port, passing through narrow channels, conducting naval gunfire support, and performing boat control.

Entries in the radar navigation log include (1) identification of landmarks used (including latitude and longitude of each point, if necessary); (2) bearings, ranges, CPAs to landmarks, and times of observations; (3) set and drift; and (4) course and speed change recommendations sent to conn. The time of each entry must be recorded.

Q1. What ship's operational data form is used for the surface radar contact log?

Q2. What type of information is contained in the radar navigation log?

RECORDS

In the previous section, we discussed using logs to record operational information. Certain other information concerning CIC personnel also should be recorded, but not in a log format. In this section, we will discuss briefly some of that information and note that it is kept in documents known simply as *records*.

A smooth-functioning CIC is the result of teamwork; teamwork is developed by practice (drills). During drills, CIC personnel have the opportunity to perfect the skills that they already have and to develop new skills by learning to operate other CIC stations. This cross-training provides CIC with personnel who can perform more than one assignment, such as operating detection equipment, plotting, and using communications equipment. As personnel gain new skills, their training should be documented in training records.

A CIC petty officer assigned duties as a training PO must schedule frequent drills that include having personnel operate under casualty conditions. Such drills help to ensure that each member of the team knows what action to take in the event of fires, personnel injuries, and loss of or damage to equipment. The dates and results of these drills should be documented in some type of record.

By now, you should be able to see that unless a comprehensive record is maintained concerning the capabilities of each individual, training effectiveness in CIC will be diminished.

Personnel Qualification Standards (PQS) records must be kept current, with all objectives met on time. A record of completion must be entered in the person's

service record. PQS provides an excellent record of a Sailor's progress and capabilities.

OPERATIONS PLANS AND ORDERS

To perform CIC functions intelligently, Operations Specialists must have certain advance information. Two major sources of such information are the operation plan (OpPlan) and the operation order (OpOrder). The ship's communication plan, derived from the communication annex, is of special interest because it supplies pertinent communication information in advance. In the following paragraphs, you will learn the basic difference between OpPlans and OpOrders. For detailed information concerning operation plans and operation orders, refer to *Naval Operational Planning,* NWP 5-01.

OPERATION PLAN

An operation plan (OpPlan) is a directive issued by a senior command for operations over a large geographical area and, usually, for a considerable period of time. Ordinarily, it is based upon, and therefore restricted by, various assumptions. It is prepared well in advance of the impending operation and becomes effective when directed by the issuing authority The OpPlan is the instrument upon which subordinate commanders base directives to their commands covering specific tasks.

OPERATION ORDER

An operation order (OpOrder) is a directive issued by a commander to subordinates that specifies how an operation should take place. No assumptions are included in the OpOrder and, unless otherwise stated, it is effective from the time and date specified. In most respects, the format of the OpOrder is similar to that of the OpPlan.

Q3. What type of information is contained in an OpPlan?

NAVAL WARFARE PUBLICATIONS

Naval warfare publications provide current, approved U.S. Navy tactics, doctrine, procedures, and terminology. These publications incorporate the results of fleet tactical development and evaluation (TAC D&E) programs and fleet experience, and provide information about capabilities and limitations of equipment and systems. They include other pertinent data supplied by systems commands, laboratories, and other naval organizations.

Naval warfare publications serve as a ready reference for current tactics, doctrine, and procedures and as a basis for orientation and training programs. They may be consulted for study material and professional knowledge.

The term *naval warfare publications* refers to Naval Warfare Publications (NWPs), Fleet Exercise Publications (FXPs), Allied Tactical Publications (ATPs), Allied Exercise Publications (AXPs), and USN addenda to various Allied publications.

As an OS, you should also be familiar with the following documents: Lessons Learned, Tactical Memorandum (TACMEMO), Tactical Notice (TACNOTE), and Fleet Tactical Notice (FLTACNOTE).

Lessons Learned is almost self-explanatory. It contains information gleaned from previous actions or operations that is or may be useful in planning and conducting future actions or operations To qualify as a lesson learned, an item must reflect "value added" to existing policy, organization, training, education, equipment or doctrine such as:

(1) Identifying problem areas, issues, or requirements and, if known, suggested resolutions.

(2) Identifying the need for specific, assignable, and accountable action to create, update, modify, clarify, or cancel a portion of or an entire tactic, procedure, system, general information document, etc. with regard to existing policy, organization, training, education, equipment, or doctrine.

(3) Modifying existing or experimental policy or doctrine, tactics, techniques, and procedures.

(4) Providing information of general or specific interest in operations planning and execution, (e.g., scheduling considerations, procedure/system checklists, etc.).

A **TACMEMO** is a proposed tactic distributed for evaluation. A TACMEMO is automatically canceled after 2 years if it is not reissued, replaced by a TACNOTE, or made part of an NWP.

A **TACNOTE** is a tactic that has been fully evaluated and accepted as an approved tactic for use by the appropriate operational command and units. TACNOTEs are automatically canceled 2 years after publication unless they are reissued or incorporated into an appropriate NWP.

A **FLTACNOTE** is a type of TACNOTE that has been coordinated with, and accepted by, all fleet commanders in chief (CINCs). FLTACNOTEs are approved by a CNO letter of promulgation for Navywide use until the tactics are published in an NWP.

Most NWPs and TACMEMOs/TACNOTES are now distributed on CD-ROMs called the *Navy Tactical Information Compendium (NTIC)*, Series A and Series B. The NTIC is a product the Naval War College. NTIC Series A contains a variety of naval tactical warfare databases including TACNOTEs, TACMEMOs, and Lessons Learned. NTIC Series B contains naval warfare publications and related databases such as Fleet Exercise Publications (FXPs), Experimental Tactics (EXTACs), and Naval Doctrine Publications (NDPs).

NAVAL WARFARE PUBLICATIONS LIBRARY

The NWPL is the central point within a command where NWPs are administered and maintained. The purpose of NWPL administration is to ensure that all required publications are held, updated, and made available to users. The overall management of a command's NWPL is the responsibility of the NWP custodian. Day-to-day management of the publications and the account, in general, may be delegated to an NWPL clerk or an NWPL account subcustodian. NWPs are distributed on CD-ROMs and no longer available in book format.

Binders for U.S. naval warfare publications are color-coded according their security classifications. The color codes used are as follows:

- Top Secret - Pink
- Secret - Red
- Confidential - Yellow
- Unclassified - Blue

All NATO publications have, or will have, a white binder regardless of their security classification. NATO publications are kept separated from NWPs for security reasons.

The following basic requirements must be met in maintaining a naval warfare publications library (NWPL). A complete list of the duties of the NWPL custodian and subcustodians is contained in chapter 4 of NWP 1-01, *Naval Warfare Publication System.*

1. The required allowance must be on board and readily available for use.
2. Publications must be maintained, corrected, and kept up to date.
3. Classified publications must be handled, stowed, and transmitted as required by applicable security directives.

Handling Considerations

All naval warfare publications must be safeguarded and accounted for as required by their security classification. Special handling procedures are contained in the *Department of the Navy Information Security Program Regulation*, SECNAVINST 5510.36 and the *Naval Warfare Publication Guide*, NPW 1-01, supplemented where necessary by individual letters of promulgation. If a conflict arises between any of your publications, follow the directions in *Department of the Navy Information Security Program Regulation*, SECNAVINST 5510.36.

If you receive authorization to extract information from naval warfare publications for use in training or operations of U.S. forces, be sure to satisfy the following conditions:

1. Have all extracts properly marked with their security classification and safeguarded according to *Department of the Navy Information Security Program Regulation*, SECNAVINST 5510.36.
2. Obtain prior approval from ACNO (Intelligence) before you extract or reproduce material marked Restricted Data or NOFORN.
3. Obtain prior approval according to *Cryptographic Security Policy and Procedures Manual*, CMS 1A, before you extract material from Communications Security Material Systems publications.

Storage of Classified Material

Commanding officers are responsible for safeguarding all classified information within their commands and for ensuring that classified material not in actual use by appropriately cleared personnel, or under their direct observation, is stored in the manner prescribed.

Storage refers to the manner in which classified material is protected by physical or mechanical

means. The degree of protection necessary depends on the classification, quantity, and scope of the material. The following general rules apply to all documents:

- Because of the increased risk of theft, valuables, such as money, jewels, precious metals, narcotics, etc., may not be held in containers used to store classified material.
- Containers may not have external markings that indicate the level of classified information stored within them. However, for identification purposes, the exterior of each security container may bear an assigned number or symbol.
- Files, folders, or groups of documents must be conspicuously marked to ensure their protection to a degree as high as that of the highest classified document included. Documents separated from the file, folder, or group must be marked as prescribed for individual documents.

Accountability

Accountability requirements vary, depending on the classification level assigned to the document. The requirements become more specific and strict as the level of classification increases.

At every command, a standard, continuous chain of receipts for Top Secret material is required. A disclosure record form is attached to each Top Secret document that circulates within a command or activity. Each person having knowledge of its contents must sign the form. All Top Secret information (including copies) must be continuously accounted for, individually serialized, and entered into a command Top Secret Log. The log must completely identify the information and, as a minimum, include the date the document was originated or received, individual serial numbers, copy number, title, originator, number of pages, disposition (i.e., transferred, destroyed, transmitted, downgraded, declassified, etc.) and date of each disposition action taken. Top Secret materials must be physically sighted or accounted for at least annually, and more frequently as circumstances warrant.

The accountability requirements for Secret materials are less specific. Each command establishes administrative accountability procedures for Secret materials that it originates or receives based on its operating environment. The same leeway also applies to Confidential materials.

SUBCUSTODY OF NAVAL WARFARE PUBLICATIONS

Persons who are properly cleared may sign for, and retain custody of, NWP publications drawn from the NWPL. As subcustodians, they are responsible for the accountability, safeguarding, and maintenance of all publications in their custody.

The NWPL publications clerk is responsible for the preparation and proper execution of all NWPL transactions, record keeping, and other duties associated with the NWPL.

When the NWPL receives an NWP change, the NWPL clerk will enter the change in the publication unless it is in subcustody, in which case the clerk will use a Change Entry Certification (OPNAV Form 5070/12) (fig. 4-6) to ensure that the subcustodian enters the change.

CHANGES AND CORRECTIONS

All publications must be changed periodically to keep them current. When changes arrive, they must be entered accurately and immediately, as soon as they are effective, to ensure that their associated publications are reliable sources of information. You may be given changes to make in various publications that are retained in CIC. If so, follow the directions supplied with the change. A change may consist of pen-and-ink corrections, a cutout, or page insertions issued to amend or add to the contents of a basic publication. Changes are serially numbered, as change No. l, change No. 2, etc. Some changes bear register numbers that are assigned independently. The register number of a change has no relationship to the register number of the basic publication.

When you enter a change or correction, follow the steps listed below:

1. Check the foreword or the Letter for the effective date of the change or correction and ensure that the publication to be corrected is also effective.
2. Read the specific instructions contained in the change or correction carefully before you begin the actual entry.

CHANGE ENTRY CERTIFICATION
OPNAV 5070/12 (REV. 6-75)

RETURN TO NAVAL WARFARE
PUBLICATIONS LIBRARY

SHORT TITLE	COPY NO.	CHANGE	EFFECTIVE DATE

REMARKS

I certify that the above change or correction has been entered and the list of effective pages was checked against the contents of the basic publication, and the superseded pages and residue of the change were returned to the Naval Warfare Publications Library.

NOTE: *Missing pages or other defects should be reported in the REMARKS space above.*

SIGNATURE	ENTRY DATE

PART 2 S/N 0107-LF-050-7061

SHORT TITLE	COPY NO.	CHANGE	EFFECTIVE DATE

REMARKS:

I acknowledge receipt of the above change and certify that this change will be entered upon the effective date/immediately and that the superseded pages will be returned to the Naval Warfare Publications Library within five (5) working days thereafter.

SIGNATURE	DATE

PART 1 S/N 0107-LF-050-7061 C-3500

OS310406

Figure 4-6.—Change Entry Certification, OPNAV 5070/12.

3. Remove old pages and add new pages very carefully. Sometimes the number of pages to remove is different from the number of pages to add.

4. For lengthy pen-and ink changes, either cut the new text out of the correction sheet (if possible) or type the new text on a separate piece of paper. Delete, in ink, all matter superseded by the cutout before you insert the cutout. Then paste the change onto the page to be changed. Fold any excess paper into a flap if there is no room to cement the entire cutout on the page. Use rubber cement or mucilage, which is more satisfactory than glue or gummed tape. Gummed tape often causes pages to stick together and impairs usage or may cause pages to tear if removal is attempted.

5. For actual pen-and ink changes, use any dark ink except red. (Red ink is not visible under the red nightlights used at sea.) After you have entered the pen-and-ink correction, note in the margin adjacent to the entry the source of the correction.

6. Conduct a page count by using the list of effective pages (fig. 4-7). When you finish the page count, enter the appropriate information on the Record of Changes page (fig. 4-8).

Effective Pages	Page Numbers
Original	I (Reverse Blank)
Original	III, IV
Change 1	V, VI
Original	VII thru IX (Reverse Blank)
Original	1-1, 1-2
Change 1	1-3 thru 1-8
Original	2-1 thru 2-6
Original	3-1 thru 3-23 (Reverse Blank)
Original	4-1 thru 4-28
Change 1	4-29 thru 4-49 (Reverse Blank)
Original	5-1 thru 5-26
Original	6-1 thru 6-33 (Reverse Blank)
Original	7-1 thru 7-10
Change 1	7-11,7-12
Original	7-13 thru 7-36

Effective Pages	Page Numbers
Original	8-1 thru 8-8
Original	9-1 thru 9-28
Original	A-1, A-2
Original	B-1 thru B-3 (Reverse Blank)
Original	C-1 thru C-9 (Reverse Blank)
Original	D-1 thru D-3 (Reverse Blank)
Original	E-1 (Reverse Blank)
Original	F-1 thru F-5 (Reverse Blank)
Change 1	Index-1, Index-2
Original	Index-3 thru Index-6
Change 1	Index-7 thru Index-10
Original	Index-11 (Reverse Blank)
Change 1	LEP-1 (Reverse Blank)

OS310407

Figure 4-7.—List of Effective Pages.

RECORD OF CHANGES

Change No. and Date of Change	Date of Entry	Page Count Verified by (Signature)
#1-4 Jun 98	*6 Jun 98*	*OSCM P. H. WILLIAMS*

OS310408

Figure 4-8.—Record of Changes and Corrections.

PUBLICATION INVENTORY

To provide positive control of publications kept in CIC, a watch-to-watch inventory of the publications is used. At the change of the watch, the watches jointly conduct a sight inventory of every publication. By signing the watch-to-watch inventory, the relieving watch certifies that it sighted all of the publications and that it accepts responsibility for them. Any discrepancies must be resolved before the watch is relieved. All signatures must be in ink. A sample of a watch-to-watch publication inventory is shown in figure 4-9.

SAMPLE NWPL LIST

The following NWPL list consists of publications that should be held by a "typical" combatant CIC. Actual publications will vary according to ship type.

1. NWP 1-01: *Naval Warfare Publications Guide.*

   NWP 1-01 is a guide to the naval warfare publication system, including periodic reviews and procedures, publication procurement, a general summary of each publication, and guidance for the operation of a naval warfare publications library (NWPL).

PUBLICATION CUSTODY LOG

WATCH-TO-WATCH PUBLICATION INVENTORY FOR CIC

Short Title	Reg.Nr.	Day-Month-Year Period of Watch: 9 Feb 99 00-04	9 Feb 99 04-08	9 Feb 99 08-12	9 Feb 99 12-16	9 Feb 99 16-18	9 Feb 99 18-20	9 Feb 99 20-00	10 Feb 99 00-04	10 Feb 99 04-08	10 Feb 99 08-12						
ATP 1 (B) VOL 1	A6239	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓						
ATP 4		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓						
ACP 165		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓						
ACP 125		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓						
ATP 1 (B) VOL II		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓						
JANAP 119		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓						
COM 7TH FLEET OPLAN 1-87		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓						
COMCARGRU 6 OPORD 1-87		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓						
(FULL) Signature (In ink)																	

I certify that I have personally sighted and inventoried each of the above-listed publications and/or materials. By my signature above I acknowledge responsibility for maintaining security precautions and assume custody for all above-listed publications and/or materials during my watch or until properly relieved of their custody. I will report immediately to the custodian or other competent authority any discrepancy in the inventory.

OS310409

Figure 4-9.—Publication Custody Log. (Example)

2. NWP 1-02 *Naval Terminology.*

NWP 1-02 is a glossary of the most commonly used terminology of naval warfare.

3. NWP 6-01: *Basic Operational Communications Doctrine.*

NWP 6-01 establishes the basic doctrine, policies, and principles governing operational communications.

4. NWP 1-03.1: *Operational Reports*.

Part I summarizes the operational reports required by the CNO, fleet commanders, and operational commanders. Part II establishes movement report (MOVEREP) requirements.

5. NWP 3-56: *Composite Warfare Commander's Manual*

NWP 3-56 contains Composite Warfare Concepts and the Composite Warfare Chain of Command.

6. NWP 5-01: *Naval Operational Planning*.

NWP 5-01 presents the planning process related to the conduct of naval warfare for operations, logistics, communications, intelligence, and psychological warfare.

7. NWP 1-10.1: *Tactical Action Officer Handbook*.

NWP 1-10.1 provides the tactical action officer (TAO) with rote-type information, which he might momentarily forget in a rapidly developing situation but may need quickly to make a tactical decision.

8. NWP 4-01.4: *Replenishment at Sea*.

NWP 4-01.4 describes operational procedures and equipment for the replenishment of ships at sea.

9. NWP 3-50.1: *Navy Search and Rescue (SAR) Manual.*

NWP 3-50.1 provides guidance to units assigned SAR responsibilities. This manual is intended to promote and maintain standardization of U.S. Navy SAR procedures and techniques within the service.

10. NWP 3-02.1: *Ship-to-Shore Movement*

NWP 3-02.1 presents the planning and execution of ship-to-shore movements and the organization, functions, and tactical employment of the naval beach group during amphibious operations.

11. NWP 3-01.01: *Antiair Warfare.*

NWP 3-01.01 details AW organizattion and doctrine; it also includes missile, nuclear, amphibious, and air intercept procedures.

12. NWP 3-13.1.13: *Electronic Warfare Coordination*.

NWP 3-13.1.13 provides doctrine and procedures for electronic warfare.

13. NWP 3-04.1M: *Helicopter Operations*.

NWP 3-04.1M describes the mandatory operational procedures and training requirements for the shipboard employment of helicopters.

14. NWP 3-22.5-ASW TAC: *Air ASW TACAID*.

NWP 3-22.5 ASW TAC provides USW flight crews and USW air controllers with rote-type information, which they may forget in a rapidly developing situation but may need quickly to make a tactical decision. It also contains factual information indexed and tabbed for fast use in multithreat tactical naval warfare.

15. NWP 3-21.51.3: *Surface Ship Passive Localization and Target Motion Analysis*.

NWP 3-21.51.3 describes in detail the theory and technical application of TMA, using the sonar systems and ranging techniques applicable for surface ships.

16. FXP 1: *Submarine and Antisubmarine Exercises*.

FXP 1 establishes tactics and procedures for conducting submarine and antisubmarine exercises, with criteria for evaluating results.

17. FXP 2: *Air and AAW Exercises*..

FXP 2 presents procedures and tactics for conducting aircraft exercises, as well as criteria for evaluating the exercises.

18. FXP 3: *Ship Exercises*.

FXP 3 provides exercises for all types of ships and guidance for observers in evaluating the exercises.

19. FXP 3-2: *Preparation, Conduct, and Analysis of a Battle Problem*.

FXP 3-2 provides guidance for planning and conducting the umpire/observer operation in the larger competitive exercises.

20. AAP 6: *NATO Glossary of Terms and Definitions for Military Use.*

    AAP 6 promotes effective communications within NATO by providing standardized terminology for military use.

21. APP 1: *Allied Maritime Voice Reporting Procedures.*

    APP 1 contains examples of procedures used on various voice channels: USW Air Coordination Net (USWAC-NET), USW Control Net (USW-NET), Surface Reporting Net (SR-NET), and Air Warfare Nets (AW-NETS). This publication gives examples of how action may develop during different phases of an operation.

22. ATP 1(C), Volume I: *Allied Maritime Tactical Instructions and Procedures.*

    ATP 1(C), Volume I contains basic maneuvering instructions, tactics, and procedures for all Allied navies. A USN Addendum provides additional basic material for intra-service use by the U.S. Navy when it operates separately from other Allied navies.

23. ATP 1(C), Volume II: *Allied Maritime Tactical Signal Book.*

    ATP 1(C), Volume II contains standard maneuvering, operating, and common administrative signals. A USN Addendum provides additional basic material for intra-service use by the U.S. Navy when it operates separately from other Allied navies.

24. AXP publications.

    AXPs provide information on conducting Allied exercises and criteria for evaluating those exercises.

Q4. What document contains information on a proposed tactic for evaluation by fleet units?

Q5. What publication contains information on the Naval Warfare Publication System?

DESTRUCTION OF CLASSIFIED MATERIAL

Destruction of classified material falls into two categories—routine and emergency. Destruction, when authorized or ordered, must be complete, and classified material must be destroyed as soon as it is no longer needed.

Unclassified material, including formerly classified material that has been declassified, unclassified messages, and For Official Use Only (FOUO) material, does not require the same assurances of complete destruction. To avoid overloading a command's classified material destruction system, don't destroy unclassified material unless the commanding officer or higher authority requires the destruction because of unusual security considerations or efficiency. Unclassified naval nuclear propulsion documents are an exception and, whenever practical, must be disposed of in the same manner as classified documents. When disposal in the same manner as classified documents is not feasible, the command concerned must devise an alternative method that will provide an adequate degree of control during and after disposal. Specific methods depend on local conditions, but the method used must afford reasonable protection against unauthorized recovery of naval nuclear propulsion information.

DESTRUCTION PROCEDURES

The level of security classification of the material being destroyed determines the destruction procedures used. These procedures are established by *Department of Navy Information Security Program Regulation*, SECNAVINST 5510.36.

1. The destruction of classified material must be witnessed by personnel who have a security clearance at least as high as the level of the material being destroyed. Two witnesses are required for destruction of Top Secret and Secret material. The witnessing officials must be thoroughly familiar with the regulations and procedures for safeguarding classified information and must:

   a) safeguard burn bags containing classified material according to the highest classification of the material they contain;

   b) observe the complete destruction of the classified documents or the burn bags containing classified material;

c) check the residue to ensure that destruction is complete and that reconstruction is impossible; and

d) take precautions to prevent classified material or burning portions from being carried away by wind or draft.

2. A record of destruction must be completed for Top Secret material and for special types of information outlined in paragraphs 7-7 and 10-17 of SECNAVINST 5510.36 (No record is required for the destruction of classified working papers, classified waste, Secret or Confidential material). The record may have any format, as long as it includes a complete identification of the information destroyed (originating command, subject, effective date, number of copies, etc.) and the date of destruction. It must be completed by two witnesses when the information is placed in a burn bag or actually destroyed and must be retained for 5 years.

3. When Top Secret material is placed in a burn bag for central disposal, the record of destruction must be signed by the witnessing officials at the time the material is placed in the burn bag. Burn bags must then be destroyed following the procedures given in paragraph 1 above.

Routine Destruction

The destruction of superseded and obsolete classified materials that have served their purpose is called *routine destruction*.

The approved methods are burning, pulping, pulverizing, and shredding. Every member of the destruction detail should know exactly what is to be destroyed and should double-check each item before it is destroyed. Because classified messages and trash accumulate quickly and storage space is limited, these materials are generally destroyed daily. All material must be watched until it is completely destroyed. If you are directed to burn the classified material, be sure the documents are separated into individual pages and placed loosely into the burn bag. After the documents have burned, break up the ashes and sift through them to ensure the material has been completely destroyed.

Unclassified and FOUO (For Official Use Only) messages do not have a national destruction requirement. However, your command may require their destruction to avoid the possibility of message traffic analysis by unauthorized individuals, which could be detrimental to national security.

Emergency Destruction

Commands located outside the United States and its territories, all deployable commands, and all commands holding COMSEC material must have (and practice) a procedure for destroying classified material to prevent its capture by enemy forces. The procedure is normally based on factors such as those listed below:

1. The level and sensitivity of the classified material held by the activity

2. The proximity of land-based commands to hostile or potentially hostile forces or to communist-controlled countries

3. Flight schedules or ship deployments in the proximity of hostile or potentially hostile forces or near communist countries

4. The size and armament of land-based commands and ships

5. The sensitivity of the material or the command's operational assignment

6. The potential for aggressive action by hostile forces

As part of the planning for emergency destruction, each command should take the following measures:

1. Reduce the amount of classified material it holds.

2. Emphasize the priorities for destruction, designation of personnel responsible for destruction, and the designation of places and methods of destruction.

3. Authorize the senior individual present in an assigned space containing classified material to deviate from established plans when circumstances warrant.

4. Emphasize the importance of beginning destruction sufficiently early to preclude loss of material. The effect of premature destruction is considered inconsequential when measured against the possibility of compromise.

5. Conduct drills periodically to ensure that personnel responsible are familiar with the emergency plan. The drills help the command evaluate the effectiveness of the emergency

destruction plan and equipment and serves as the basis for improvements in planning and equipment use.

For commands holding COMSEC material, additional emergency destruction guidance is contained in CMS 1A, Cryptographic Security Policy and procedures Manual.

PRIORITY FOR EMERGENCY DESTRUCTION—.In your command's emergency destruction plan, all classified materials must be assigned a priority for emergency evacuation or destruction. The priorities will be based on the potential effect that a loss of the materials to an enemy will have on the national security.

Cryptographic material (COMSEC) has the highest priority for emergency destruction. Insofar as is humanly possible, it must not be permitted to fall into enemy hands. Other classified matter is destroyed in order of classification—highest classification first.

The priorities for emergency destruction are as follows:

1. Priority One. Top Secret material in the following order: (a) COMSEC material; (b) Special Access material; (c) other material
2. Priority Two. Secret material in the following order: (a) COMSEC material; (b) Special Access material; (c) other material
3. Priority Three. Confidential material in the following order: (a) COMSEC material; (b) Special Access material; (c) other material

During an emergency destruction situation, you may use the following methods, in addition to routine classified material destruction equipment, to destroy classified material:

1. Jettisoning or sinking, under the following conditions:
   a) Material. Refer to CMS 1A for criteria for jettisoning and sinking COMSEC material.
   b) Other Material. You may jettison classified material at sea at depths of 1,000 fathoms or more. If that water depth is not available and if time does not permit other means of emergency destruction, you may still jettison the material to prevent its easy capture. If your shipboard emergency destruction plan includes jettisoning, weighted bags should be available. If your ship is to be sunk through intentional scuttling or is sinking because of hostile action, be sure the classified material is locked in security filing cabinets or vaults and allowed to sink with the vessel, rather jettisoning it.
2. Dismantling or smashing metallic items beyond reconstruction by use of tools such as sledgehammers, cutting tools, and torches.
3. Using disposal equipment not normally associated with the destruction of classified material, such as garbage grinders, sewage treatment plants, and boilers.
4. As a last resort, dousing the classified material with a flammable liquid and igniting it, as an alternative to its certain loss.

Reporting Emergency Destruction

During an emergency destruction, try to keep track of the documents that are destroyed. Your command will need this information for a report it must send to the Chief of Naval Operations and other interested commands. The report will contain the following information:

1. Identification of the items of classified material that may not have been destroyed
2. Information concerning classified material that may have been presumed to have been destroyed
3. Identification of all classified material destroyed and the methods of destruction

Q6. What instruction prescribes how classified material should be destroyed?

Q7. What type of classified material has the highest precedence for emergency destruction?

ANSWERS TO CHAPTER QUESTIONS

A1. OPNAV Form 3100/5.

A2. Identification of landmarks used (including latitude and longitude of each point, if necessary); bearings, ranges, to landmarks, and times of observations; set and drift; and course and speed change recommendations sent to conn.

A3. Operational information about an operation that will take place over a large geographical area and for a considerable period of time.

A4. TAC MEMO.

A5. NWP 1-01.

A6. 5510.36.

A7. Cryptographic (COMSEC).

CHAPTER 5

RADAR FUNDAMENTALS

LEARNING OBJECTIVES

After you finish this chapter, you should be able to do the following:

1. Discuss the principles of radar and, using a block diagram, describe the basic functions, principles of operation, and inter-relationships of the basic radar system.
2. Discuss basic radio wave characteristics, including amplitude, cycle, frequency, and wavelength.
3. Discuss what affect radio wave constants such as pulse repetition rate, pulse repetition time, rest time, pulse width, and power have on the minimum and maximum ranges of a radar.
4. Identify the basic types of radar antennas and antenna components and state their uses.
5. Describe the factors that contribute to and detract from the accuracy of a radar.

INTRODUCTION

When you finish this chapter, you should be able to explain the basic principles of radar, both with block diagrams and in terms of the interrelationships between the components of a radar system. Furthermore, you will be able to explain basic radio wave characteristics, constants that affect all radar systems, and common factors that affect the proper operation of radar systems. Finally, you will be able to describe basic radar antenna systems.

EARLY HISTORY OF RADAR

Studying the history of radar is something like learning a magician's tricks. You may not be able to see how the magician makes the rabbit appear, but your mind tells you it didn't come from thin air.

Visible Light

During the 18 century, scientists accepted the theory that visible light is made up of waves of energy. They concluded that light waves have different lengths and that humans can perceive these different wavelengths as different colors. By the early part of the 19 century, scientists had discovered that visible light represents only a small part of the total energy radiated by the Sun. Most of the Sun's energy waves are invisible to the eye because their wavelengths are either too long or too short for the eye to detect. In other words, radiant energy from the Sun covers a spectrum of wavelengths, both visible and invisible.

The characteristics of these invisible waves or rays of energy have since been discovered, and are being used to our benefit. Some of these rays, X rays for example, have wavelengths so short they can penetrate many solid materials, while others, such as the waves emitted by electric power lines, are measured in miles. For the purposes of radar, we are concerned with the type called *radio waves*.

Radio Waves

James C. Maxwell, a Scottish physicist, published his theory of electromagnetism in 1873. In this theory, Maxwell mathematically predicted the existence of radio waves. He theorized that radio waves were the result of changing electrical and magnetic fields and could be created by vibrating an electric charge. Maxwell theorized further that radio waves traveled at the speed of light and would reflect when they struck an object.

In 1888 Heinrich Hertz, a German physicist, performed laboratory experiments that proved that radio waves could be generated and that their characteristics were exactly as predicted by Maxwell.

In 1895 Guglielmo Marconi, an Italian electrical engineer, began a series of experiments aimed at transmitting radio waves over long distances. With

equipment modeled after Hertz's apparatus, he succeeded in transmitting signals across the English Channel in 1899. Two years later, he transmitted a radio signal across the Atlantic.

The radio waves that Marconi used to transmit his radio signal happened to be very long waves. The shortest radio waves are called *microwaves*. Both microwaves and longer radio waves are used in the operation of radar. Look at the electromagnetic spectrum, shown in figure 5-1.

DEVELOPMENT OF RADAR

In 1922, Marconi announced that he had noticed the reflection of radio waves by objects many miles away. As a result, he predicted that radio waves could be used to detect objects at great distances.

During that same year, two American scientists working at the Naval Research Laboratory in Washington, D.C., A. Hoyt Taylor and Leo C. Young also recognized the principles of reflected radio waves. Between 1922 and 1930, they conducted further tests which proved the military value of these principles by detecting objects hidden by smoke, fog, or darkness. This was the beginning of radar (RAdio Detection And Ranging) as we know it today.

During the 1930s, alerted by the Taylor-Young experiments, the British developed their own radar. They called it a *radio locator.* By 1940, the British had developed radar to such a degree that they were very successful in detecting and shooting down many enemy aircraft during the Battle of Britain.

Recognizing the importance of radar, the U.S. Navy ordered it for its ships in 1936. The first vessel to use radar was the battleship USS *New York*, in 1938.

During the early days of World War II, people heard about the "magic eye." This mysterious new device could pierce the darkness, fog, and weather to give warning by providing visual presentations of approaching enemy ships and aircraft. It was rumored that distant shore lines, landmarks, and other aids to navigation could also be picked up by the "eye" and displayed on a viewing screen. These rumors were confirmed in 1943 when the United States announced that it had been using an operational radar system for several years.

Since World War II, radar development, both by military and commercial laboratories, has progressed so rapidly that today radar has unlimited uses. Commercially, radar is being used for safety and navigation in aircraft and large and small ships, for tracking aircraft and controlling aircraft landings, for detecting and tracking weather, and for tracking tiny satellites in the vast regions of outer space. Practically all Navy ships now have complex radar systems. We will discuss the principles and operational uses of these systems and their related equipment in this chapter and in others in this book.

PRINCIPLES OF RADAR

The principles upon which radar operates are very similar to the principles of sound-wave reflection. If you shout in the direction of a cliff or some other sound-reflecting surface, you will hear an echo. What actually happens is that the sound waves generated by the shout travel through the air until they strike the cliff. There they are reflected, returning to the originating spot, where you can hear them as weak echoes. A certain amount of time elapses between the instant the sound leaves your mouth and the instant you hear the echo. You notice this time interval because sound waves travel through air at a relatively slow rate (1,100 feet per second). The farther you are from the cliff, the longer this time interval will be. If you are 2,200 feet from the cliff when you shout, about 4 seconds will pass before you hear the echo. In other words, it takes 2 seconds for the sound waves to reach the cliff and 2 seconds for them to return to you.

Radar is an application of radio wave principles. It is possible to detect the presence of objects, to determine their direction and range, and to recognize their character. Detection involves directing a beam of radio-frequency waves over a region to be searched. When the beam strikes a reflecting object, some the beam's energy is reflected. A very small part of this reflected energy is returned to the radar system. A sensitive receiver, located near the transmitter, detects the echo signal and causes it to be presented visually on a viewing scope. The radar system can determine direction (bearing) and range because the receiving system can be made directional and can make extremely small time measurements. This process is illustrated in figure 5-2.

Radar systems may vary greatly in design. Depending on data requirements, they may be simple or complex. But, the principles of operation are essentially the same for all systems. Therefore, we can use a basic radar system to demonstrate the functional performance of any radar system. A basic pulse-modulated radar system consists of several

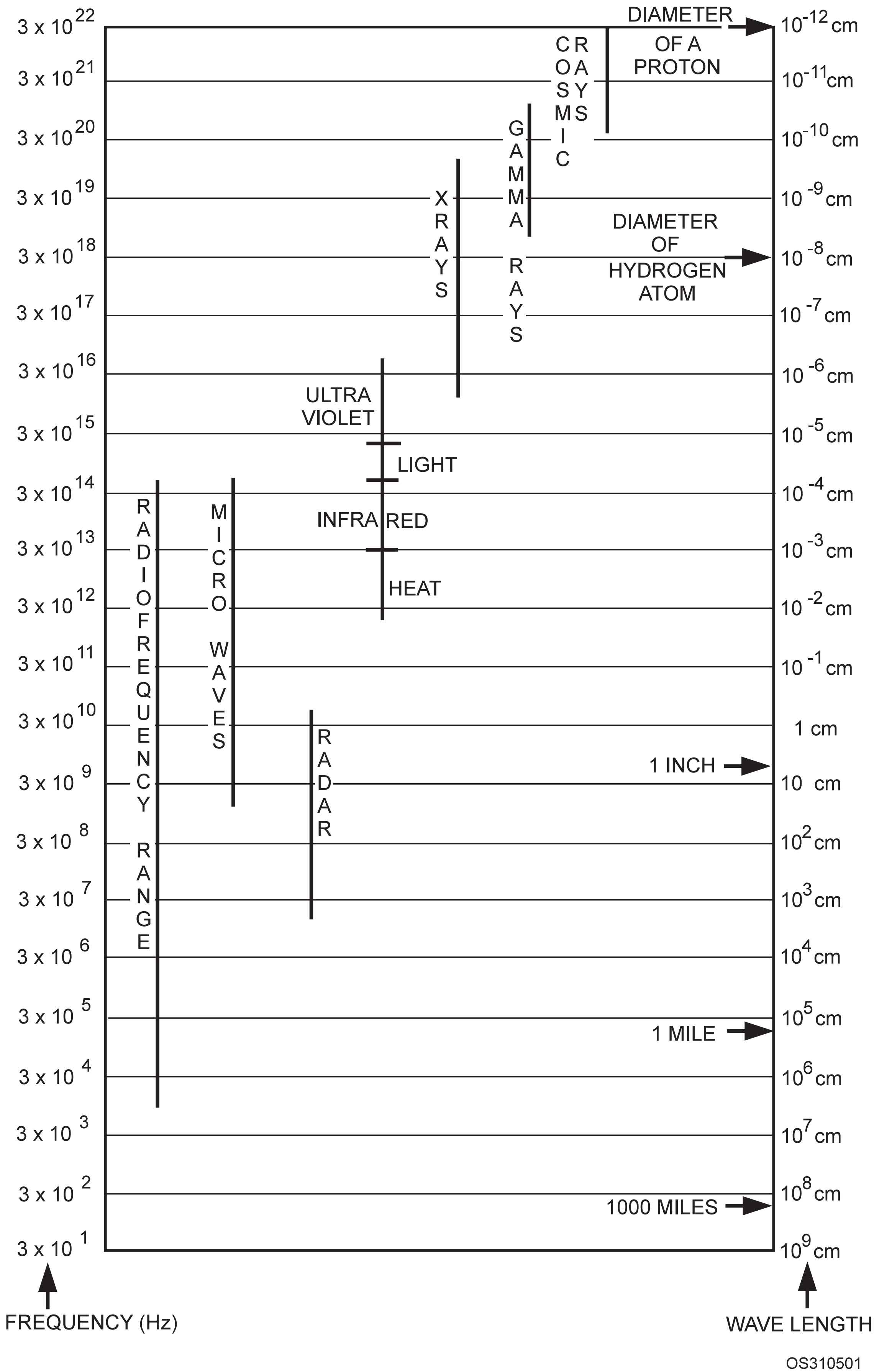


Figure 5-1.—Electromagnetic spectrum.

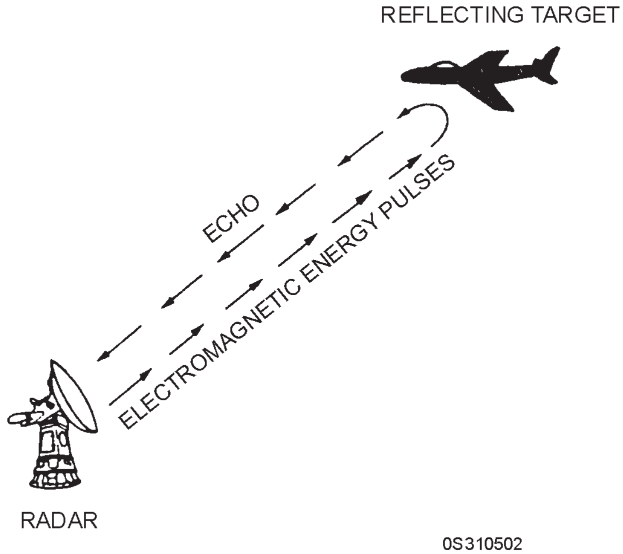


Figure 5-2.—Radar echo.

essential components. These components, shown in figure 5-3, are as follows:

- **Modulator**. The modulator produces the signals that trigger the transmitter the required number of times per second. The modulator also triggers the indicator sweep and coordinates the other associated circuits.

- **Transmitter**. The transmitter generates radio frequency (RF) energy in the form of short, powerful pulses.

- **Duplexer**. The duplexer permits the use of a common transmission line and a single antenna for both transmitting and receiving.

- **Antenna System**. The antenna system takes the RF energy from the transmitter and radiates it in a highly directional beam. The antenna system also receives any returning echoes and passes them to the receiver.

- **Receiver**. The receiver amplifies the weak returning echoes and produces them as video pulses to be applied to the indicator.

- **Indicator**. The indicator produces a visual trace of the area being searched by the radar and accurately displays the returning video echo on this trace.

- **Power Supply**. The power supply (not shown) furnishes all of the dc and ac voltages necessary for the operation of the system components.

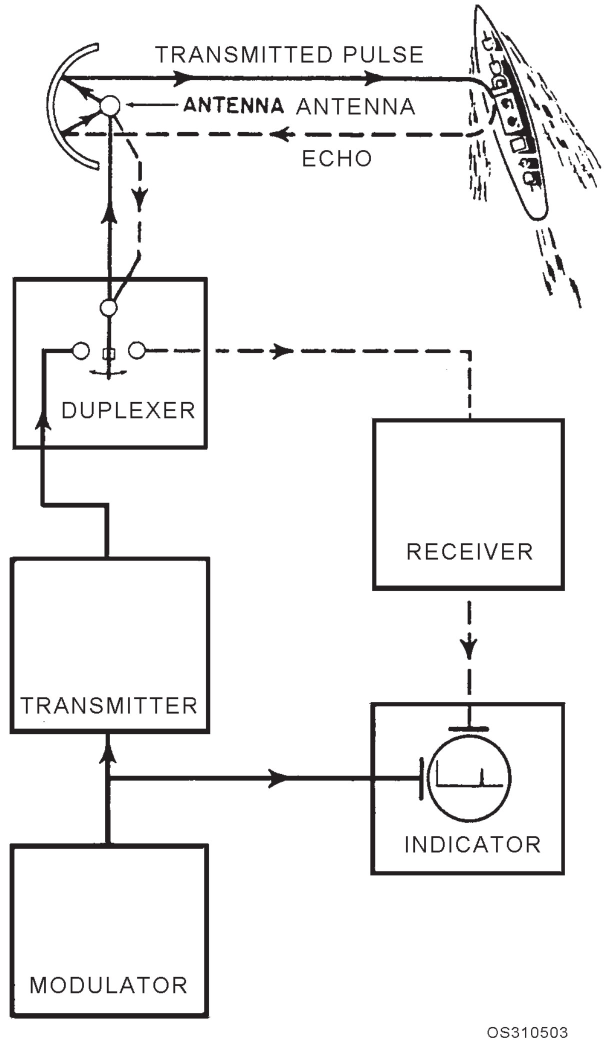


Figure 5-3.—Block diagram of a fundamental radar system.

Q1. What component of a radar system generates the radio frequency energy in the form of short, powerful pulses?

Q2. What component of a radar system amplifies weak returns and presents them as video pulses?

RADIO WAVE CHARACTERISTICS

Radio frequency (RF) waves travel through space at the speed of light—186,000 *statute* miles per second. You will see this speed used in most commercial publications on radar. In the Navy, however, all distances are expressed in terms of the *nautical* mile. The nautical mile is actually slightly longer than 6,000 feet, but the Navy uses 6,000 feet (or 2,000 yards) as a nautical mile for all gunnery,

navigation, and radar applications. Therefore, for naval purposes, the speed of light is 164,000 nautical miles, or 328,000,000 yards, per second.

Radio waves have four basic characteristics: **amplitude, cycle, frequency**, and **wavelength.**

Amplitude is the measure of a wave's energy level. It is the maximum instantaneous value of the wave's alternating current, measured in either a positive or a negative direction from the average level.

A *cycle* is one complete reversal of an alternating current, starting at zero and going through a positive peak, then a negative peak, and back to zero. See figure 5-4

Wave *frequency (f)* is the number of cycles occurring in 1 second. The standard unit of measurement of radio frequency (RF) is the *hertz*. One cycle per second is equal to 1 hertz (Hz). Most radio frequencies are expressed in kilohertz (1 kHz = 1,000 hertz) or in megahertz (1 MHz = 1,000,000 hertz).

Since cycles occur at a regular rate, a definite interval of time is required to complete each cycle. This time interval is known as the wave's *period* (T). Mathematically, the time required for one cycle is the reciprocal of the wave's frequency; that is, $T=1/f$. A wave that has a frequency of 200,000,000 hertz has a period of 0.000,000,005 second.

Wavelength (λ) is the space occupied by one cycle; it may vary from several miles to a fraction of an inch. Wavelength is usually measured in meters, but on occasion it is expressed in feet. Since a radio wave travels at a constant speed, wavelength may be determined by dividing wave velocity (v) by wave frequency (f).

Q3. *What are the four basic characteristics of radio waves?*

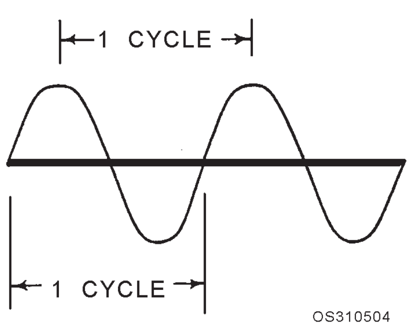


Figure 5-4.—The cycle.

RADAR SYSTEM CONSTANTS

Earlier you learned that radio waves travel through space at 164,000 nautical miles per second. This is a constant that is common to all radars. It is one of several constants that you must be familiar with to gain maximum performance from your radar equipment. Every radar system has a certain set of constants, based on its tactical use, accuracy required, range to be covered, and physical size. (Although the term *constant is* used, some characteristics are often variable, such as pulse repetition rate and pulse width.). We discuss some of those constants below.

CARRIER FREQUENCY

Carrier frequency (f_c) is the frequency at which the transmitter operates. System designers base the selection of this frequency on the desired directivity and range of the radar. The carrier frequency, in turn, dictates the physical size of the radar antenna.

Inside radar transmitters, specially constructed electron tubes, called magnetrons, generate and amplify RF energy. The output frequency of this energy is the radar's carrier frequency. As long as the pulse from the modulator is applied, the magnetron will continue to oscillate. The modulator, then, determines how often and for how long the RF oscillator is turned on.

PULSE REPETITION RATE (PRR)

The modulator turns the transmitter on long enough for it to put out a short pulse of RF energy, and then turns it off for a relatively long period. During the long period between pulses, the receiver "listens" for a returning echo. The number of times the transmitter is turned on each second is known as the *pulse repetition rate (PRR)* of the radar. For example, a radar that is turned on 500 times each second has a pulse repetition rate of 500 pulses per second (pps).

PULSE REPETITION TIME

Pulse repetition time varies inversely with pulse repetition rate; that is, PRT = 1/PRR. A radar having a PRR of 500 pps, for example, has a PRT of 0.002 second, or 2,000 microseconds.

REST TIME

Rest time (RT) is the time between radar pulses. It is during this time that the radar receiver "listens" for returning echoes.

PULSEWIDTH

Pulsewidth (PW) is the actual time that a radar transmits. The duration of the trigger pulse from the modulator to the transmitter determines the pulse width of a radar. Since the amount of energy transmitted during each radar pulse is proportional to pulsewidth, a radar's pulsewidth affects its detection range. The chances of detecting distant targets are better if more energy is transmitted. For this reason, a long-range search radar normally has a very large pulsewidth. Figure 5-5 shows the relationship between PRR, PRT, RT, and PW.

POWER RELATIONSHIP

There are two types of RF power associated with a radar transmitter: peak power and average power. *Peak power* is the power contained in the radiated pulse. This is the useful power of the transmitter. Peak power only occurs while the transmitter is transmitting. If the value of peak power is spread over an entire "operating-resting" transmitter cycle, it becomes a lower value, called *average power.* Because the radar transmitter rests for a long period of time, average power is relatively low compared to peak power.

You should have noticed by now that all of the constants are related in some manner. Consider the following relationships. If all other factors remain constant, the greater the pulsewidth, the higher the average power. Also; the longer the pulse repetition time, the lower the average power. These general relationships are shown in Figure 5-6.

The constants also affect the radar's physical characteristics. Every transmitter has an operating (duty) cycle. The duty cycle is simply the ratio

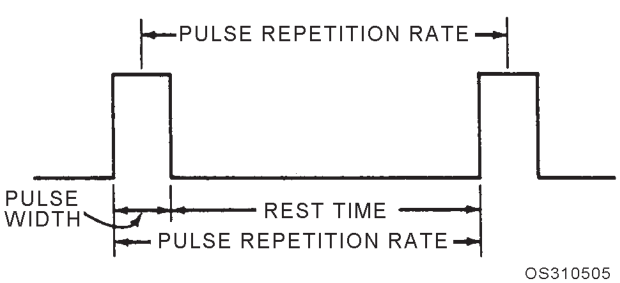


Figure 5-5.—Radar pulse relationships

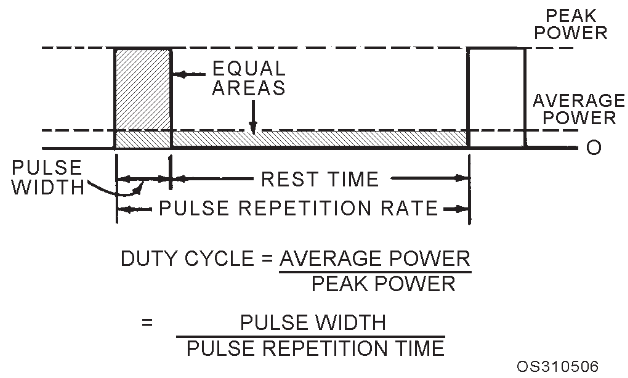


Figure 5-6.—Relationship of peak power and average power.

(expressed as a percentage) of the time the transmitter spends transmitting RF energy to the entire time it is on during a transmit-rest cycle. Since the physical size of many electronic components is determined by the amount of power they have to radiate, the physical size of a radar transmitter is determined by its average power requirement, which is indicated by its duty cycle.

The transmitter's pulse repetition rate also affects the radar's physical size. A transmitter with a low PRR can provide very high peak power with reasonably low average power. A high peak power is desirable in order to produce a strong echo over the maximum range of the equipment. On the other hand, low average power permits the transmitter tubes and circuit components to be smaller and more compact. Thus, it is advantageous to have a low PRR (reflected by a low duty cycle).

TIME-RANGE RELATIONSHIP

The radar indicator (scope) provides a video presentation of the targets detected by the radar system. The indicator is basically a timing device that accurately displays, on a time base (sweep), the positions of radar targets. It does this by computing the time lapse between the instant the radar is pulsed and the instant the radar detects a returning echo. See figure 5-7. Each time the modulator triggers the radar transmitter, it also triggers the sweep in the indicator and starts the timing. The sweep moves across the scope for a period of time equal to the PRT of the radar. At the end of this time, the radar pulses again, and the indicator sweep jumps back to its point of origin and starts all over again. If an echo returns during the sweep time, the radar receiver instantaneously converts it into a video signal and applies it to the indicator on a grid that indicates the range of the target from the radar. Depending on the type of indicator, target pips are

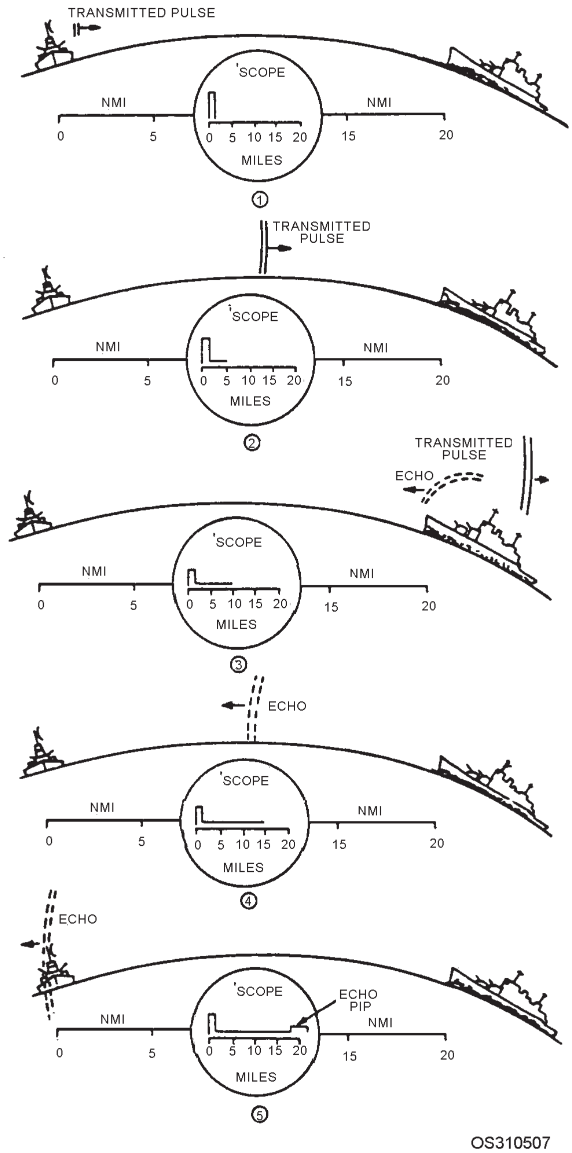


Figure 5-7.—Radar range determination.

displayed either as vertical displacements on a horizontal sweep or as intensified spots on a circular sweep.

The propagation velocity of RF energy is 328 yards per microsecond (µs). Search radars are calibrated on the basis of 2,000 yards per nautical mile, which provides sufficient accuracy for their function. For search radars, then, it takes 6.1 µs for an RF pulse to travel 1 nautical mile, or 12.2 µs per radar nautical mile (round-trip distance).

Assume that a pulse of 1 µs duration is transmitted toward a ship 20 nautical miles away. In part 1 of Figure 5-7, the pulse is just leaving the antenna. In part 2, 61 µs later, the pulse has traveled 10 nautical miles toward the target. The scope is marked off in nautical miles, and at this point the horizontal trace on the scope has reached only the 5-nautical-mile mark, or half the distance actually traveled by the pulse. In part 3, the pulse has reached the target 20 nautical miles away; the echo has started back, and part of the transmitted pulse continues beyond the target; 122 µs have elapsed, and the scope reads 10 nautical miles. In part 4, 183 µs after the start of the initial pulse, the echo has returned half the distance from the target. In view 5, the echo has returned to the receiver, and a pip is displayed on the scope at the 20-nautical mile mark. Actual distance traveled by the pulse is 40 nautical miles, and total elapsed time is 244 µs.

Various kinds of indicators are used as radar repeaters. The most familiar indicator in use today is the plan position indicator (PPI).

The PPI scope (fig. 5-8) provides a bird's-eye view of the area covered by the radar. Your ship is in the center. The sweep originates in the center of the scope and moves to the outside edge. This straight-line sweep is synchronized with the radar antenna and rotates 360°. Therefore, the PPI provides bearing and range information. Each time a target is detected it appears as an intensified spot on the scope.

To obtain target position, the PPI is equipped with a bearing cursor and a range strobe. The bearing cursor, like the sweep, appears as a bright line. It can be rotated manually through 360°. Bearing information is obtained by rotating the cursor to the center of the target. The target bearing is then read directly from the bearing dial. The range strobe appears as a bright spot riding on the cursor. As the range crank is turned clockwise, the strobe moves out from the center. Range is obtained by placing the strobe on the leading edge (edge closest to the center of the PPI) of the target. The target range is then read directly from the range dials, either in nautical miles or yards.

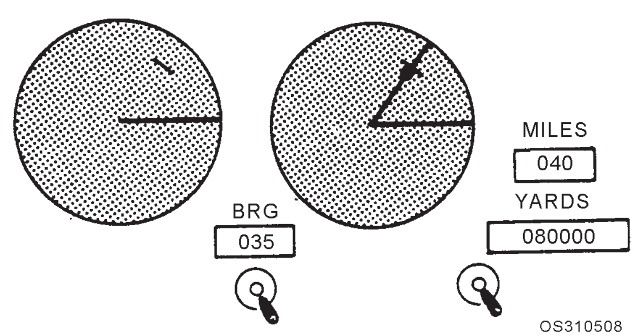


Figure 5-8.—(U) PPI displays.

MAXIMUM RANGE

One of the factors considered when a radar is being designed is the range to be covered. Many of the system constants have some effect on maximum range. But the constant that has the most effect is the PRR. Therefore, we say that the maximum theoretical range of a radar is determined by the PRR.

Sufficient time must be allowed between each transmitter pulse for an echo to return from any target located within the maximum range of the system. If the PRR is increased, the time between pulses decreases. This means that the transmitter pulse travels a shorter distance before the radar pulses again. Therefore, the range covered by the radar is decreased when the PRR is increased.

Suppose you need to determine the maximum theoretical range of a radar. One formula you may use, if you know the radar's PRT, is:

$$\text{maximum range} = \frac{PRT}{12.2} \text{ (in } \mu\text{s)}$$

Suppose radar #1 has a PRR of 500 pps, with a PRT of 2,000 μs. The maximum theoretical range is 164 nautical miles, computed as follows:

$$\text{maximum range} = \frac{2{,}000}{12.2} = 164 \text{ nautical miles}$$

Now consider radar #2, which has a PRR of 2,000 pps. The PRT is 500 microseconds (1/2,000 pps), and the maximum theoretical range is 41 nautical miles.

$$\text{maximum range} = \frac{500}{12.2} = 41 \text{ nautical miles}$$

Another formula you can use to determine maximum theoretical range is the following:

$$\text{maximum range} = \frac{82{,}000}{PRR}$$

Considering round trip time at the speed of light, we know that RF energy will travel 82,000 nautical miles and return in 1 second. The total distance traveled, of course, is 164,000 nautical miles; thus, the 82,000 factor in our second formula. Now apply this formula to the two radars we just discussed.

For radar #1:

$$\text{maximum range} = \frac{82{,}000}{500} = 164 \text{ nautical miles}$$

For radar #2:

$$\text{maximum range} = \frac{82{,}000}{2{,}000} = 41 \text{ nautical miles}$$

As you can see, the end result is the same using either of the two methods. The situation will dictate which of the two methods you should use. The important point is that you understand both methods.

If all conditions were perfect, the *actual* maximum range capabilities of a radar would be equal to the theoretical maximum range. However, a target is seldom detected at the maximum theoretical range, because many other factors affect the actual maximum range. You cannot determine the effects of these factors mathematically; but since they exist, we will discussed them at this point.

Frequency. Radio-frequency waves are attenuated as they travel through space (We will explain attenuation later.). The higher the frequency, the greater the attenuation. Lower frequencies, therefore, have generally been superior for use in long-range radars.

Pulsewidth. The longer the pulsewidth, the greater the range capabilities. If the amount of radiated energy is increased, the chances of detecting targets at greater ranges are increased.

Beamwidth. A more concentrated beam has a greater range capability since it provides higher energy density per unit area.

Antenna rotation rate. The slower an antenna rotates, the greater the detection range of the radar. When the antenna rotates at 10 rpm, the beam of energy strikes each target for one-half the time it would if the rotation were 5 rpm. During this time, a sufficient number of pulses must be transmitted in order to return an echo that is strong enough to be detected. Long-range search radars normally have a slower antenna rotation rate than radars designed for short-range coverage.

Target composition. Targets that are large can be detected at greater ranges. Conducting materials, such as metals, give the best reflections. Non-conducting materials, such as wood, return very weak echoes. An aircraft carrier will be detected at a greater range than a destroyer will. Likewise, a metal craft will be detected at a greater range than a wooden craft of comparable size.

Receiver sensitivity. A more sensitive receiver will detect a weak echo sooner. Radar receivers are tuned frequently to ensure maximum performance.

MINIMUM RANGE

We know that RF energy travels at the rate of 328 yards per microsecond. If an echo is received 1 microsecond after a radar pulses, the range to the target is 164 yards. The energy traveled 164 yards to the target and 164 yards back to the radar system, a total distance of 328 yards, in 1 microsecond. Here again, we must consider round-trip distance. For radar ranging, in terms of yards, the velocity is considered to be one-half of its true value, or 164 yards of range per microsecond. This principle is applied in determining the minimum range of a radar.

The minimum range at which a target can be detected is determined largely by the width of the transmitted pulse. If a target is so close to the radar that the echo is returned to the receiver before the transmitter is turned off, the reception of the echo will be masked by the transmitter pulse. For example, a radar that has a PW of 1 microsecond cannot detect an echo returned within 1 microsecond. In other words, this particular radar cannot detect a target located within 164 yards. The formula for minimum range is:

minimum range = PW (in μs) $\times$ 164.

If a radar has a PW of 5 microseconds, its minimum range is

PW $\times$ 164 = 5 $\times$ 164 = 820 yards.

This means that any target located within 820 yards of this radar will not be detected. Only those targets located at distances greater than 820 yards will be detected.

Receiver recovery time also affects minimum range. So that the receiver will be protected while the radar is transmitting, the path to the receiver is blocked. When the transmission ends, an electronic switch is triggered and a very slight delay is created. This delay is called receiver recovery time. Although normally quite small, receiver recovery time does have some effect on minimum range.

RANGE RESOLUTION

Individual contacts in a group do not show up separately on a scope unless there is sufficient distance between them. The ability of a radar to give separate indications of individual targets is called *resolution*. Range resolution is the ability of a radar to distinguish between two targets on the same bearing but at slightly different ranges. See figure 5-9. Range resolution, like minimum range, is determined by the pulsewidth of the radar.

Energy is reflected from a target for the duration of the transmitted pulse. To the radar that has a pulsewidth of 1 microsecond, every target appears to be 164 yards wide. If a 1-microsecond pulse is sent toward two objects that are on the same bearing but separated by 164 yards, the leading edge of the echo from the distant target will coincide in space with the trailing edge of the echo from the nearer target (fig. 5-10). As a result, the echoes from the two objects will blend into a single pip, and range can be measured only to the nearer object.

For a radar to distinguish between two targets on the same bearing, they must be separated by a distance greater than PW $\times$ 164. For instance, a radar that has a PW of 3 microseconds will distinguish each of two targets on the same bearing if they are separated by a distance greater than 3 $\times$ 164, or 492 yards.

Q4. What radar constant is the actual time the radar transmits?

Q5. To determine maximum range of a radar, what radar constant must you know?

ANTENNA SYSTEMS

We mentioned earlier that radar systems are used to obtain range and bearing information on targets. Antennas are the primary devices that allow radar systems to provide this information. Some of the early radars used single, omnidirectional antennas for both

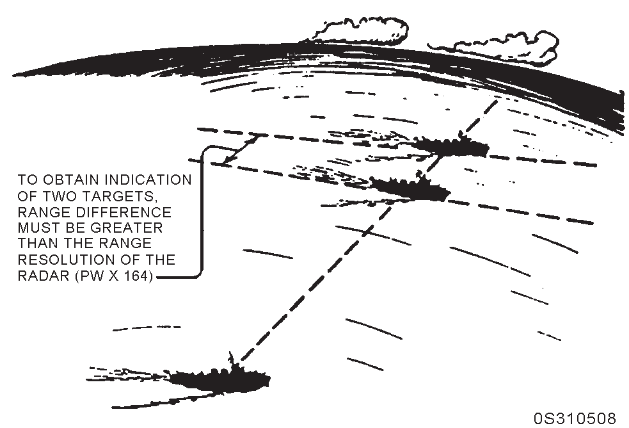


Figure 5-9.—Range resolution.

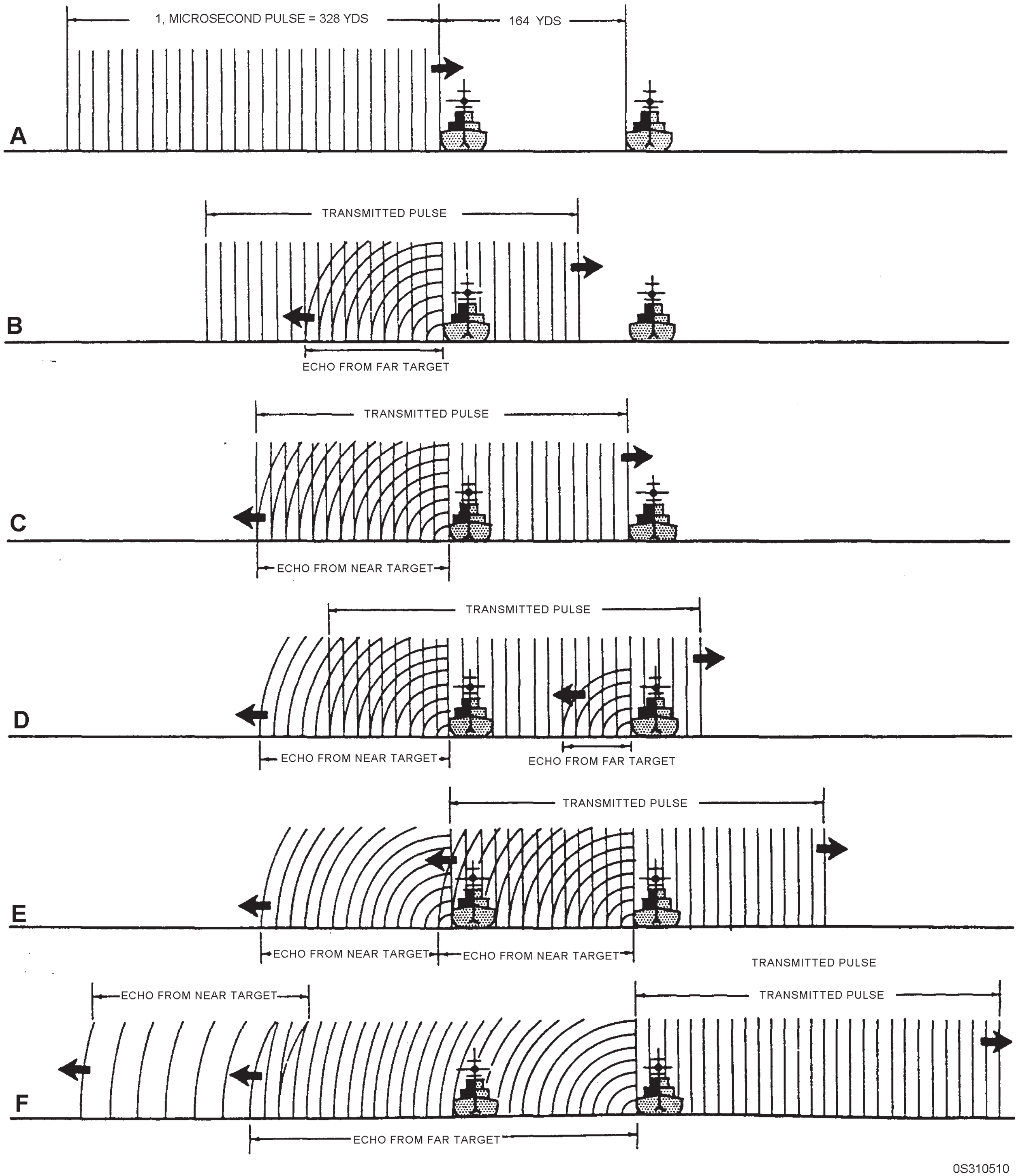


Figure 5-10.—Minimum target separation required for range resolution.

sending and receiving. Others used two antenna systems, one for transmitting and one for receiving. Neither of these methods is acceptable in search radar applications today because they can provide only range information.

Today's search radars use a single rotating antenna or a fixed antenna with a rotating beam. Each of these antennas radiates the energy from the transmitter in a specific direction that continually changes. It then receives returning echoes and passes them to the

receiver. A typical single radar antenna system consists of the following three essential components:

1. An antenna that radiates the RF energy as a concentrated beam and receives any returning echoes. (In general, the term *antenna* is applied to the entire antenna array, which includes the actual radiating element and associated directors and reflectors.)
2. Transmission lines to conduct the RF energy from the transmitter to the antenna and from the antenna to the receiver.
3. An electronic switch (duplexer) that alternately shifts the system between transmit and receive functions.

ANTENNAS

An antenna can be as complex as the AN/SPY-1 fixed array found on AEGIS ships or as simple as the parabolic reflector used with the AN/SPS-67 radar. Each antenna operates basically in the same manner but will provide different presentations and information to the operator.

Radar antennas radiate RF energy in patterns of LOBES or BEAMS that extend outward from the antenna in only one direction for a given antenna position. The radiation pattern also contains minor lobes, but these lobes are weak and normally have little effect on the main radiation pattern. The main lobe may vary in angular width from one or two degrees for some antennas to 15 to 20 degrees for other antennas. The width depends on the radar system's purpose and the degree of accuracy required.

Directional antennas have two important characteristics, DIRECTIVITY and POWER GAIN. The *directivity* of an antenna refers to the degree of sharpness of its beam. If the beam is narrow in either the horizontal or vertical plane, the antenna is said to have high directivity in that plane. Conversely, if the beam is broad in either plane, the directivity of the antenna in that plane is low. Thus, if an antenna has a narrow horizontal beam and a wide vertical beam, the horizontal directivity is high and the vertical directivity is low.

When the directivity of an antenna is increased, that is, when the beam is narrowed, less power is required to cover the same range because the power is concentrated. Thus, the other characteristic of an antenna, *power gain*, is introduced. This characteristic is directly related to directivity.

The power gain of an antenna is the ratio of its radiated power to that of a reference (basic) dipole. The higher the gain of an antenna, the more efficient the antenna. The gain of a particular antenna is determined the manufacturer or another designated agency using laboratory-type measurement techniques. The basic dipole has long been used as the basic standard for measuring gain. During gain measurements, both antennas are excited or fed in the same manner and radiate from the same position. A single point of measurement for the power-gain ratio is set up within the radiation field of each antenna. An antenna with high directivity has a high power gain, and vice versa. The power gain of a single dipole with no reflector is unity. An array of several dipoles in the same position as the single dipole and fed from the same line has a power gain of more than one; the exact figure depending on the directivity of the array.

Common Antenna Types

We mentioned earlier that one of the purposes of an antenna is to focus the transmitted RF energy into a beam having a particular shape. In the next few paragraphs, we will discuss the more common shapes of antennas and the beams they produce.

PARABOLIC REFLECTOR.— Radio waves (microwaves) behave similarly to light waves. Both travel in straight lines; both may be focused and reflected. If radio waves are radiated from a point source into open space, they will travel outward in a spherical pattern, like light waves from a light bulb. This spherical pattern is neither too sharp nor too directive. To be effective, radio waves must be sharply defined, with a PLANE wave front, so that all of the wave front moves move forward in the same direction. A parabolic reflector is one means of changing a spherical wave front into a plane wave front.

In figure 5-11, a point-radiation source is placed at the focal point **F.** The field leaves this antenna with a spherical wave front. As each part of the wave front reaches the reflecting surface, it is shifted 180, degrees in phase and sent outward at angles that cause all parts of the field to travel in parallel paths. Because of the shape of a parabolic surface, all paths from **F** to the reflector and back to line **XY** are the same length. Therefore, all parts of the field arrive at line **XY** the same time after reflection.

If a dipole is used as the source of radiation, there will be radiation from the antenna into space (dotted lines in figure 5-11) as well as toward the reflector.

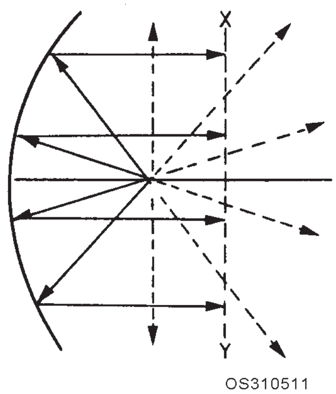


Figure 5-11.—Parabolic reflector radiation.

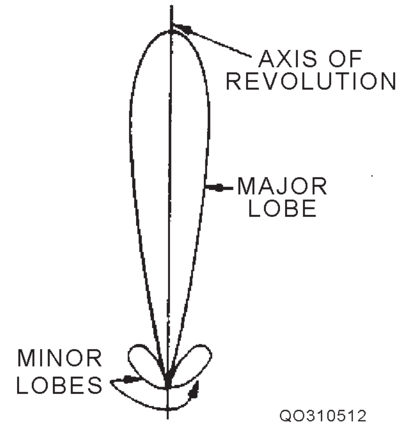


Figure 5-12.—Parabolic radiation pattern.

Energy that is not directed toward the paraboloid has a wide-beam characteristic that would destroy the narrow pattern from the parabolic reflector. This occurrence is prevented by the use of a hemispherical shield (not shown) that directs most radiation toward the parabolic surface. By this means, direct radiation is eliminated, the beam is made sharper, and power is concentrated in the beam. Without the shield, some of the radiated field would leave the radiator directly. Since it would not be reflected, it would not become a part of the main beam and thus could serve no useful purpose. The same end can be accomplished through the use of a PARASITIC array, which directs the radiated field back to the reflector, or through the use of a feed horn pointed at the paraboloid.

The radiation pattern of a parabola contains a major lobe, which is directed along the axis of revolution, and several minor lobes, as shown in figure 5-12. Very narrow beams are possible with this type of reflector. View A of figure 5-13 illustrates the parabolic reflector.

Truncated Paraboloid.—View B of figure 5-13 shows a horizontally truncated (cut off) paraboloid. Since the reflector is parabolic in the horizontal plane, the energy is focused into a narrow horizontal beam. With the reflector truncated, so that it is shortened vertically, the beam spreads out vertically instead of being focused. Since the beam is wide vertically, it will detect aircraft at different altitudes without changing the tilt of the antenna. It also works well for surface search radars to overcome the pitch and roll of the ship.

The truncated paraboloid reflector may be used in height-finding systems if the reflector is rotated 90 degrees, as shown in view C. Because the reflector is now parabolic in the vertical plane, the energy is focused into a narrow beam vertically. With the reflector truncated, or cut, so that it is shortened horizontally, the beam spreads out horizontally instead of being focused. Such a fan-shaped beam can be used to determine elevation very accurately.

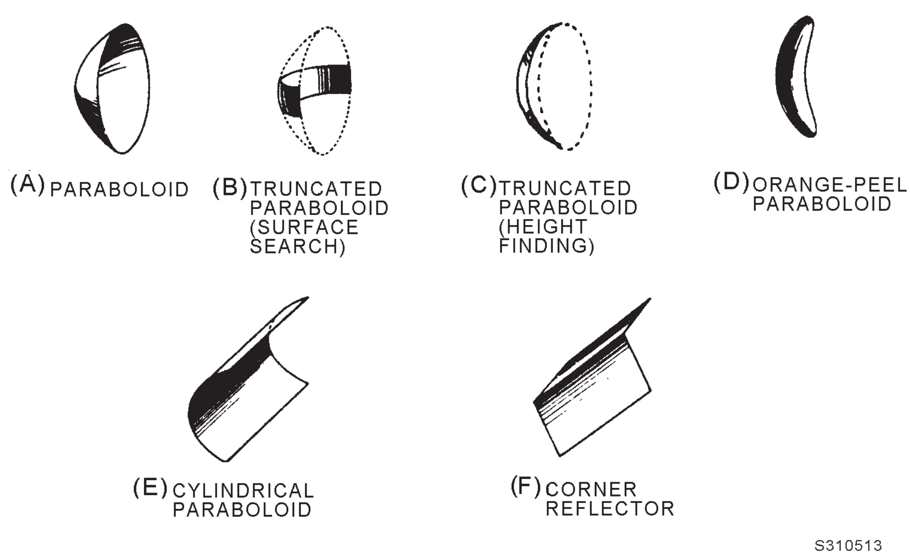


Figure 5-13.—Reflector shapes.

Orange-Peel Paraboloid.—A section of a complete circular paraboloid, often called an ORANGE-PEEL REFLECTOR because of its shape, is shown in view D of figure 5-13. Since the reflector is narrow in the horizontal plane and wide in the vertical, it produces a beam that is wide in the horizontal plane and narrow in the vertical. In shape, the beam resembles a huge beaver tail. This type of antenna system is generally used in height-finding equipment.

Cylindrical Paraboloid.—When a beam of radiated energy noticeably wider in one cross-sectional dimension than in the other is desired, a cylindrical paraboloidal section approximating a rectangle can be used. View E of figure 5-13 illustrates this antenna. A parabolic cross section is in one dimension only; therefore, the reflector is directive in one plane only. The cylindrical paraboloid reflector can be fed by a linear array of dipoles, a slit in the side of a wave guide, or by a thin wave guide radiator. Rather than a single focal point, this type of reflector has a series of focal points forming a straight line. Placing the radiator, or radiators, along this focal line produces a directed beam of energy. As the width of the parabolic section is changed, different beam shapes are obtained. This type of antenna system is used in search and in ground control approach (gca) systems.

BROADSIDE ARRAY.—The desired beam widths are provided for some vhf radars by a broadside array. The broadside array consists of two or more half-wave dipole elements and a flat reflector. The elements are placed one-half wavelength apart and parallel to each other. Because they are in phase, most of the radiation is perpendicular or broadside to the plane of elements.

SPECIAL ANTENNA TYPES.—The 3-D (air search, surface search, and height finder) radars use an antenna composed of several horizontally positioned dipole arrays stacked one on top the other. The antenna is frequency sensitive and radiates multiple frequency RF pulses, each at an elevation angle determined by the pulse's frequency. Figure 5-14 shows an example of a 3-D antenna.

The *fixed-array* antenna is the radar antenna of the future. It has numerous radiating/receiving elements placed into the face of the antenna. These elements transmit the pulse and receive the returning echoes. The fixed array antenna (Figure 5-15) is also a 3-D antenna.

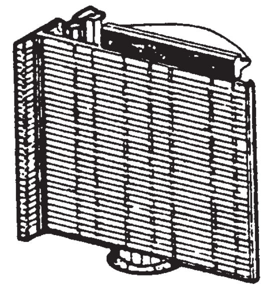


Figure 5-14.—3-D frequency scanning antenna.

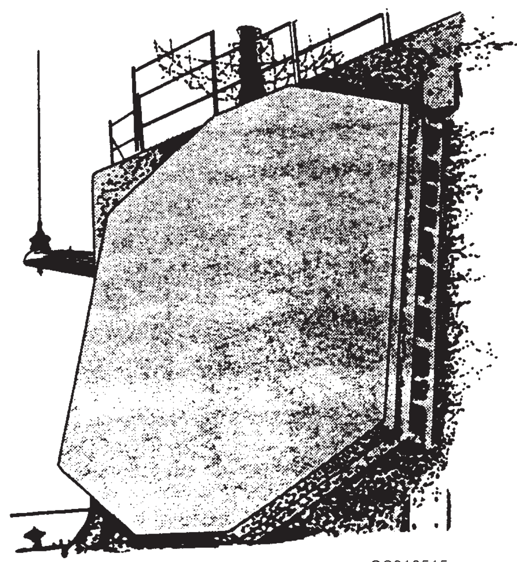


Figure 5-15.—Fixed array antenna.

ANTENNA COMPONENTS

A radar system is made up of several pieces of equipment. The antenna must be able to receive RF energy from the transmitter and to provide returning RF energy to the receiver.

To accomplish these tasks, a radar system uses transmission lines to connect the antenna to the transmitter and the receiver and a duplexer to allow the use of one antenna for both transmitting and receiving.

Transmission Lines

Transmission lines may be described as any set of conductors used to carry signals or energy from one location to another. In radar systems, they are used to carry RF energy to and from the antenna. Various types of transmission lines can be used, depending on the frequency of the radar. The two most common types are coaxial cables and waveguides.

A *coaxial cable* (fig. 5-16) consists of one conductor surrounded by another, the two being insulated from each other. The efficiency of coaxial cable decreases as frequency increases. Therefore, it is normally used only in radars that operate in the lower frequency ranges.

A *waveguide* is a hollow pipe made of a metal alloy and is either circular or rectangular in shape. This configuration allows RF energy to be transferred with very little loss in power. The size of a waveguide is determined by the frequency and power requirements of the radiated energy. In the case of the rectangular waveguide (fig. 5-17), the longer dimension is equal to one-half the wavelength of the lowest frequency it must pass. The shorter dimension determines the power-handling capability.

Duplexer

The duplexer is an electronic switching device that permits fitting a radar with a single antenna for both transmitting and receiving. During transmission, the duplexer connects the transmitter to the antenna and disconnects the receiver. This isolates the sensitive receiver from the high-powered transmitter pulse. For close targets to be seen, the duplexer must disconnect the transmitter and connect the receiver to the antenna immediately after transmission. During the reception time, the transmitter is isolated so that the returning echoes are channeled straight into the receiver with a minimum loss in signal strength.

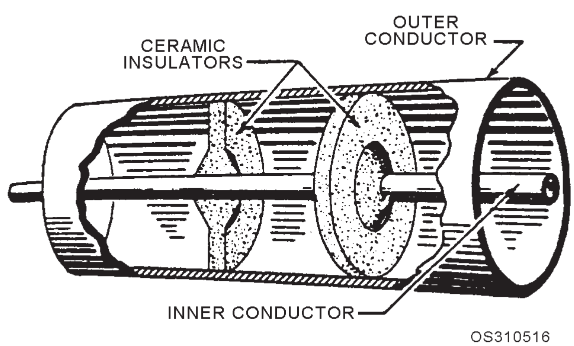


Figure 5-16.—Cross section of a coaxial cable.

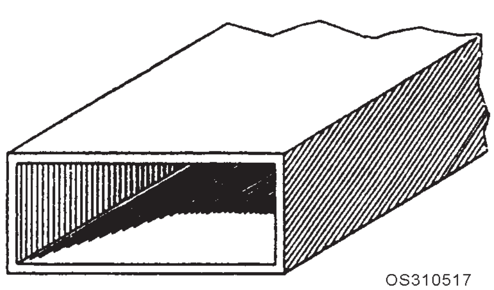


Figure 5-17.—Waveguide.

Q6. What type of radar antenna is generally used for height-finding radars?

Q7. What determines the size of the waveguide for a particular radar?

FACTORS AFFECTING RADAR OPERATION

Several factors affect radar operation. The most important of these are (1) *atmospheric conditions*, (2) *sea return*, (3) *weather*, and (4) *target height in relation to antenna height*.

ATMOSPHERIC CONDITIONS

The characteristics of the medium through which waves pass affect the manner of their transmission. Although we often assume that both light and radar waves follow straight paths, the composition of the atmosphere sometimes causes the waves to follow curved paths. Atmospheric conditions can also cause abnormally long or abnormally short radar ranges. Under certain conditions, a target that might normally be detected at 20 nautical miles may be detected at 125 nautical miles. Or the target may not be detected at all. Every radar operator must become familiar with these conditions and their causes and effects. The primary conditions that you must be familiar with are *refraction*, *diffraction*, *attenuation*, and *ducting*.

Refraction

A natural property of light rays (and radio waves) is that the direction of their transmission path changes as they pass between media having different densities. This phenomenon is called *refraction.* You can see light waves refract at sunrise and sunset. If light traveled only in a straight path, none of the sunlight would be visible whenever the Sun is below the horizon. However, this is not the case. In the short time just before sunrise and just after sunset, the sky toward the Sun is colored bright red. This is because the lower frequency rays of the sunlight, which are in the red area of the light spectrum, are refracted toward the Earth by the atmosphere, allowing you to see them. It follows, then, that lower frequency waves are affected most by refraction. Refraction is another reason why most long-range radars operate in the low frequency ranges. If it weren't for refraction, the radar horizon would be the same as the visual horizon, when in reality; the

radar horizon is approximately 25 percent farther away than the visual horizon.

Diffraction

The means by which a wave bends around the edges of an object and penetrates into the shadow region behind it is called *diffraction*. Because of diffraction, radar is sometimes capable of detecting a ship located on the opposite side of an island, or an aircraft flying behind a mountain peak.

Attenuation

Attenuation is the scattering and absorption of energy as it passes through a medium. Gases and water vapor in the atmosphere absorb some of the radio wave energy. The higher the frequency, the greater the absorption of energy.

Ducting (or trapping)

The temperature and moisture content of the atmosphere normally decrease with height above the surface of Earth. Under certain conditions, temperature may first decrease with height and then begin to increase. Such a situation is called a *temperature inversion*. The moisture content may decrease more rapidly than normal with height just above a body of water. This effect is called *moisture lapse*. Either a temperature inversion or moisture lapse, alone or in combination, may produce significant changes in refraction in the lower altitudes of the atmosphere, causing the radar signal to be "trapped" between two atmospheric layers for a certain distance, like water in a pipe. This condition may greatly extend or reduce radar ranges, depending on the direction in which the waves are bent. This is illustrated in figure 5-18.

A serious consequence of ducting is that it can mislead radar operators regarding the overall performance of their equipment. Long-range echoes caused by ducting have frequently been assumed to indicate that the equipment is in good condition when the opposite was true.

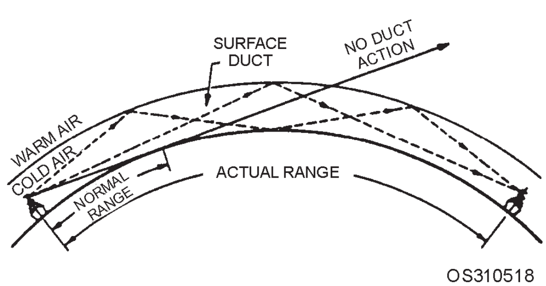


Figure 5-18.—Ducting effect on the radar wave.

SEA RETURN

Some of the energy radiated by a radar strikes the surface of the sea near the ship. Most of this energy is reflected off the waves at various angles away from the ship. Some of it is reflected back to the radar where it is detected as target echoes. These echoes are called *sea return*. In very calm waters there is almost no sea return. In rough weather, however, sea return may extend for several miles in the up-sea direction. It is very difficult to see actual targets located within the sea return because their pips are lost in the clutter of echoes caused by the sea return. Figure 5-19 illustrates how sea return appears on the PPI scope. Radars are equipped with special circuits to reduce the effects of sea return. We will discuss the manipulation of the controls for these circuits in a later chapter.

WEATHER

Since water is a very good reflector, microwave radars are very effective in detecting storm clouds and rainsqualls; large storms may completely clutter a radarscope. However, an operator can usually recognize the pips caused by ships, aircraft, or land when the scope is cluttered by weather. Pips caused by weather are normally very large and fuzzy or misty in appearance, while pips caused by ships, aircraft, or land are bright and well defined.

HEIGHT

Radar antenna and target heights are factors that help determine the initial detection range of a target. The higher the radar antenna, the greater the detection

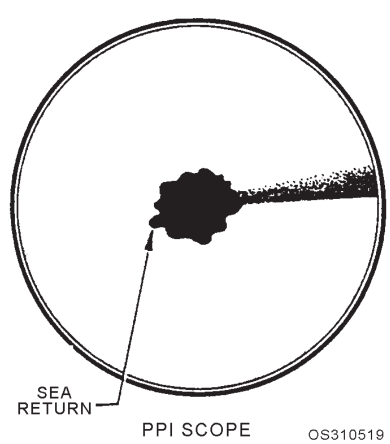


Figure 5-19.—Sea return on a PPI.

range, because the radar's field of "vision" is extended. The higher the target is above the water, the sooner it will enter the radar's field of vision. A high-flying aircraft will be detected at a far greater range than a ship; a mountain will be seen before a low coastline; and an aircraft carrier will be picked up sooner than a destroyer.

The radar range nomogram (fig. 5-20) is a convenient means of predicting the initial detection range of a particular target by your ship's radars. The height of your ship's antenna is plotted on the **h scale,** and the height of the target is plotted on the **H scale**. A line is then drawn from the point on the **h scale** to the point on the **H scale**. The point at which the line crosses the **R scale** is the predicted initial detection range. For instance, if your radar antenna is 100 feet above the waterline, an aircraft flying at 10,000 feet should be detected at 135 nautical miles. You should be aware, however, that nomogram-predicted ranges may not always be realized because of variations in atmospheric conditions (ducting) and equipment capabilities. Therefore, you must not take the predicted range capabilities as absolute.

Q8. *What atmospheric condition exists when radio waves bend around the edge of an object and penetrate into the shadow region behind the object?*

ANSWERS TO CHAPTER QUESTIONS

A1. *Transmitter.*

A2. *Receiver.*

A3. *Amplitude, Cycle, Frequency, and Wavelength.*

A4. *Pulse width.*

A5. *Pulse Repetition Time (PRT).*

A6. *range-peel paraboloid.*

A7. *The frequency and power requirements for the radar.*

A8. *Diffraction.*

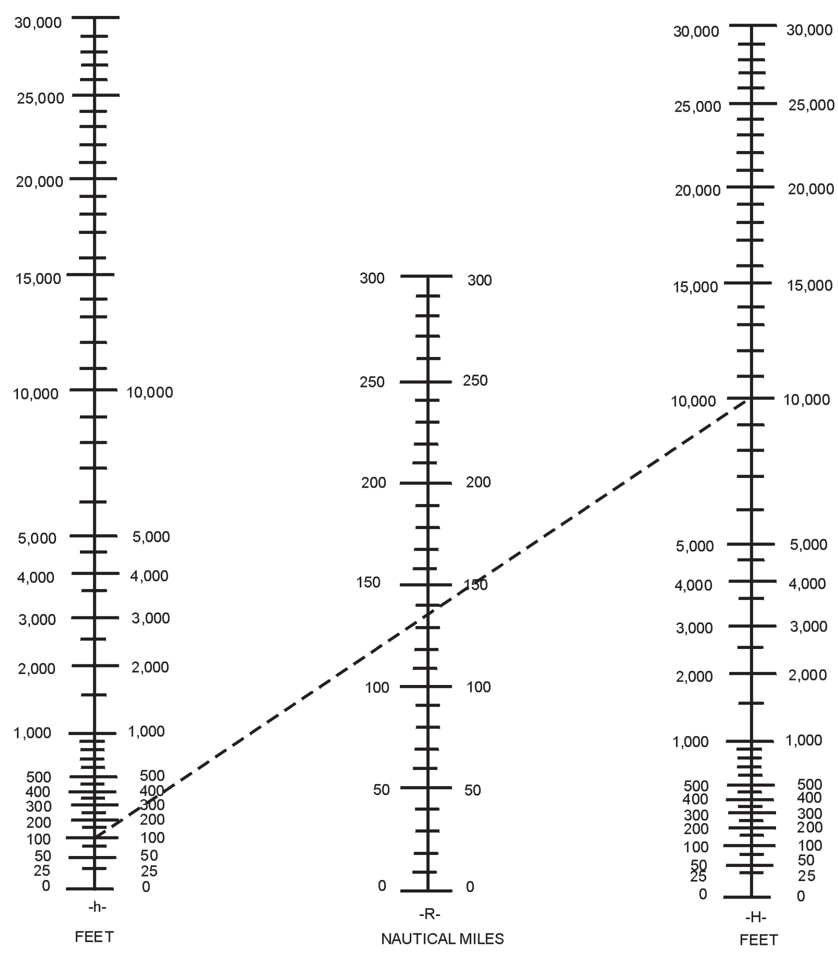


Figure 5-20.—Radar range nomogram.

CHAPTER 6

RADAR DISPLAY EQUIPMENT

LEARNING OBJECTIVES

After you finish this chapter, you should be able to do the following:

1. Identify the AN/SPA-25 G repeater controls and state their uses.

2. Recognize the various NTDS display consoles.

INTRODUCTION

When radar was first used by the military, the information it provided was displayed on a single-unit console. The console included a radar indicator ("scope") and its associated controls, and a number of receiver and transmitter controls. As the development of radar progressed, ships were furnished with more than one type of radar (air search, surface search, etc.). The displaying of radar information began to get complicated.

It soon became apparent that information from several different radars had to be available at each of several physically separated consoles. Also, in some cases, information from the *same* radar needed to be displayed in more than one way at the same time. For example, the information from an air-search radar might be needed for both air search and air control at the same time, requiring two different types of display.

The device used to display radar information is known as a *radar indicator*. Since indicators can be located at a point away from the other radar equipment, they are frequently referred to as *remote* indicators. Remote indicators are sometimes referred to as *repeaters*. The present-day remote indicator can operate with any of the search radars in use today.

Since modern naval ships are equipped with several radars and many indicators for displaying target information, the problem of getting the information from any radar to any radar repeater can be quite a problem. The obvious solution is to run a cable from each radar to every indicator, but this requires a large amount of space for the cables and adds too much weight to be practical. The accepted solution is a centralized distribution system, consisting of a distribution panel with a single input cable from each radar and a single output cable to each indicator. The system operates automatically. When an operator selects a particular radar, the switchboard connects the operator's console to the desired radar. Although the change occurs rapidly, it is complicated, in that several electronic connections are required for the inputs (timing, or trigger, pulses from the modulator; video signals from the receiver; and antenna synchronization signals for PPI sweeps).

The two most common types of displays (indicators) are as follows:

- PPI (plan position indicator) scope (range-azimuth indicator)

- NTDS scope (range-azimuth indicator)

The **PPI scope** is by far the most used radar display. It is a polar-coordinate display of the surrounding area, with own ship represented by the origin of the sweep (normally located in the center of the scope). The PPI uses a radial sweep pivoting about the center of the presentation in synchronization with the antenna to provide a map-like picture of the area covered by the radar beam. A relatively long persistence screen is used so that targets remain visible until the sweep passes again.

Bearing is indicated by the target's angular position in relation to an imaginary line extending vertically from the sweep origin to the top of the scope. The top of the scope represents either true north (when the radar is operating in true bearing) or ship's head (when the radar is operating in relative bearing).

The basic PPI screen presentation results from raw (unprocessed) video. Raw video provides only a "blip" on the indicator screen, leaving target interpretation entirely to the operator.

The **NTDS scope** is a repeater (PPI) used with Naval Tactical Data System computer-oriented equipment. It provides the operator with a processed radar display (symbology and other information), as opposed to the raw video display on the basic PPI scope. We will discuss the NTDS console in detail later in this chapter.

AN/SPA-25G

The AN/SPA-25G is an advanced navigation, air search, and tactical situation solid-state radar indicator designed for both CIC and bridge environments. It increases the operator's capabilities while decreasing his work load through a unique information display and efficient man-machine interface.

The AN/SPA-25G solves all the range, bearing and plotting problems associated with target tracking, navigation, Estimated Point of Arrival (EPA), and air traffic control. Operators can perform formerly manual plotting and range and bearing calculating tasks through the AN/SPA-25G by pushing buttons, moving its stiff stick control, and reading and viewing the solution(s) on its indicator screen.

The AN/SPA-25G's operating controls and status indicators are located on the front control panel around the CRT as shown in figure 6-1. Table 6-1 lists their

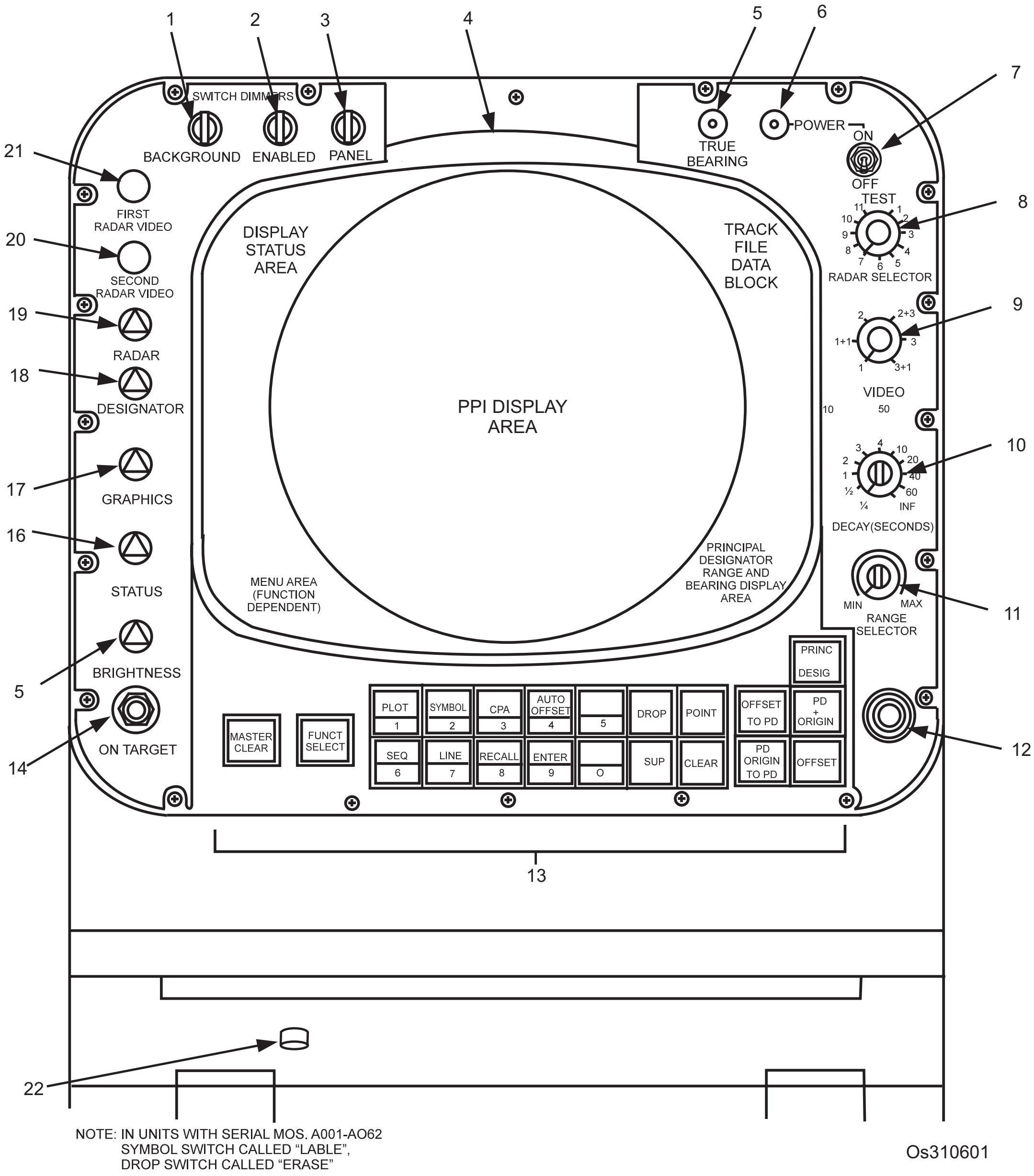


Figure 6-1.—Radar Indicator Control Panel 1A2A5 controls and indicators.

Table 6-1.—Radar Indicator Control Panel 1A2A5, Controls and Indicators
(See figure 6-1)

INDEX NO.	PANEL DESIG	FUNCTION
1	BACKGROUND SWITCH	Adjusts brightness of function switch legends when not activiated (backlit contition)
2	ENABLED SWITCH	Adjust brightness of function switch legends when actuated
3	PANEL control	Adjusts overall panel illumination (red)[1]
4	CRT display	Provides PPI and four alphanumeric status displays
5	TRUE BEARING lamp	When lit, indicates that display is present in true bearing: when not lit, display is in relative bearing. Knurled body adjusts brightness
6	POWER LAMP	Indicates that power is applied to radar indicator
7	POWER switch ON	Controls 115-volt operating power to radar indicator
8	RADAR SELECTOR	Controls external switchboard. Selects one of 11 shipboard radars and TEST function
9	VIDEO switch	Selects one of three video sources or mixed video from any two sources
10	DECAY (SECONDS)	Adjusts video signal decay time in seconds. Continuously variable from 1/ 4 SECOND to 60 SECONDS and INF (infinity)
11	RANGE SELECTOR	Adjusts range scale of displayed data. Continuously variable for range from 1/ 4 nmi to 250 nmi (1/2 nmi to 500 nmi in extended range)
12	Stiffstick control	Dedicated to adjacent function switches as activated. Controls movement and/or position of principle designator (PD) symbol, PD origin symbol, or PPI OFFSET
13	MASTER CLEAR switch	Returns display to initialization conditions
	FUNC SELECT	Enables selection or de-selection of specialized modes and conditions of operation from menus. If not active, indicator remains in general (default) node or operation
	PLOT/1 switch	Dual function. Marks position of any designated point (PLOT); numeric entry(1)
	SYMBOL/2 switch[2]	Dual function. Assigns tactical symbols; numeric entry (2)
	CPA/3 SWITCH	Dual function. Accesses predicted closest point approach between target and ownship as derived from ownship and target speed and course; numeric entry (3); in Air intercept mode it is the Forward Quarter Intercept (FQI) mode function key

[1] In serial numbers A001 through A062, panel illumination is white.
[2] In serial numbers A001 through A062, switch nomenclature is LABLE/2.

Table 6-1.—Radar Indicator Control Panel 1A2A5, Controls and Indicators
(See figure 6-1)—Continued

INDEX NO.	PANEL DESIG	FUNCTION
	AUTO OFFSET/4	Dual function. Changes PPI display from an ownship stabilized presentation (fixed center or offset) to an offset dead reckoning presentation (ownship position automatically offset at a selected rate); numeric entry (4)
	*/5 SWITCH	Dual function. Used in Air Intercept Mode to engage air targets for intercept operations; numeric entry (5)
	SEQ/6 switch	Dual function. Allows rapid sequencing through active track files; numeric entry (6)
	Line/7 switch	Dual function. Allows lines to be drawn on PPI, for example, boat lanes or helo corridors; numeric entry (7)
	RECALL/8 switch	Dual function. Returns PD to a specific plot point in a track history file; numeric entry (8)
	ENTER/9 switch	Dual function. Allows parameters used in operations or calculation, such as date, time, magnetic correction, ownship course and speed, to be entered or corrected; numeric entry (9)
	**/0 switch	Dual function. Used to request automatic assignment of numbers or deletion of number; numeric entry (0)
	DROP switch[3]	Used to delete items (plot points, track history files, lines) from storage in memory and to delete associated graphics from PPI display
	POINT switch	Designates specific items or location where actions may be performed
	SUP switch	Allows selective suppression of display information from PPI (without erasing from memory)
	CLEAR switch	Used in conjunction with other function switches to abort a procedure or to clear a process. When used with menu selection switches causes program to return to menu selection level
	OFFSET TO PD switch	Causes a PD centered PPI display
	DP ORIGIN TO PD switch	Causes PD ORIGIN symbol to move to location of PD on display
	PRING DESIG switch	Places positioning/movement of principal designator (PD) symbol under stiffstick control
	PD ORIGIN	Places positioning/movement of PD origin symbol under stiffstick control
	OFFSET switch	Causes PPI display to be offset by stiffstick control

[3] In serial numbers A001 through A062, switch nomenclature is ERASE.

Table 6-1.—Radar Indicator Control Panel 1A2A5, Controls and Indicators (See figure 6-1)—Continued

INDEX NO.	PANEL DESIG	FUNCTION
14	ON TARGET switch	Provides switch closure to external equipment via rear panel connector (not used)
15	BRIGHTNESS control	Adjusts overall brightness of CRT display
16	STATUS control	Adjusts intensity of alphanumerics and symbols within status displays (outside PPI area)
17	GRAPHICS control	Adjusts intensity of all symbols within PPI area except PD, PD origin, BL (bearing line)
18	DESIGNATOR control	Adjusts intensity of PD symbol, PD origin symbol and BL
19	RADAR control	Adjusts intensity of radar video signals
20	SECOND RADAR VIDEO	Functions with VIDEO switch. When mixed video is selected, adjusts input level of second video source
21	FIRST RADAR VIDEO	Functions with VIDEO switch. Adjusts input level of first video source when mixed video is selected; otherwise adjusts single video source selected
22	INTENSITY[4]	Illuminates right hand portion of illuminated shelf

[4] No panel marking

reference and panel designations and describes their operating functions.

For more in-depth operating information on the AN/SPA-25G, refer to NAVSEA SE251-DG-MMO, *Technical Manual for Indicator Group AN/SPA-25G Volume I.*

Q1. What function switch should you press to return the AN/SPA-25G display to its initialization condition?

Q2. What switch should you use to adjust the intensity of all symbols within the PPI area?

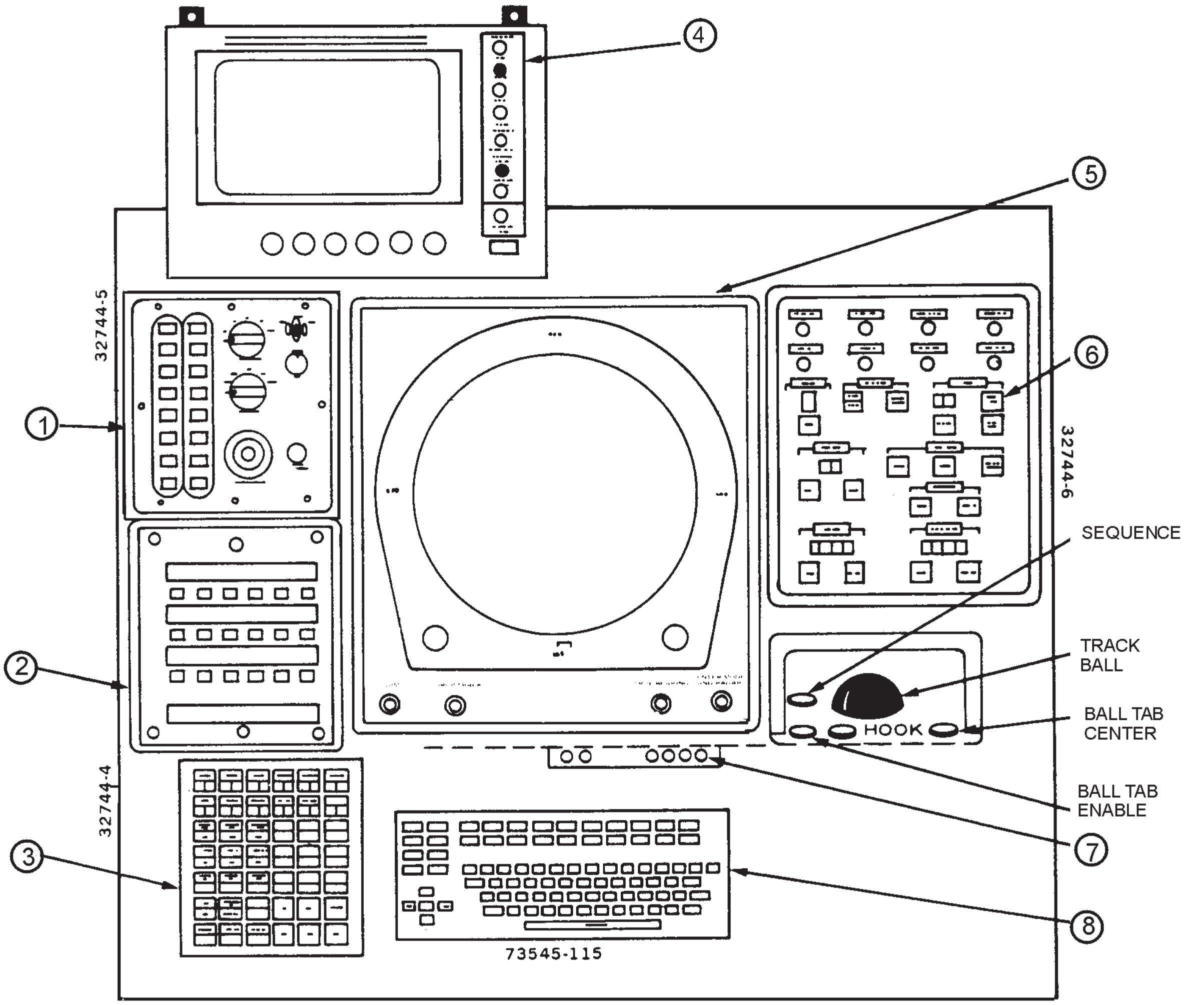
NTDS CONSOLES

Depending on what class of ship you are on, you will be using different types of Naval Tactical Data System (NTDS) display consoles. There are two basic types of display consoles, the AN/UYA-4 consoles and the AN/UYQ-21 display consoles. The NTDS PPI display consoles can display both conventional radar data and symbols denoting tactical information about the radar contacts. Symbology helps the command structure to completely and rapidly define the current tactical situation. It also is a means of communicating data and orders to, and receiving processed information from, the computer program.

AN/UYA-4 DISPLAY CONSOLES

Aside from the computer, the console is the principal hardware component of the NTDS. There are two basic AN/UYA-4 display consoles. The first is the OJ-194 console. (See figure 6-2.) There are several versions of the OJ-194 console, so refer to your ship's equipment System Operations Manuals (SOMs) for specific operating instructions.

The other AN/UYA-4 console is the OJ-197 Operations Summary Control (OSC) Console (figure 6-3). This is a stand-up Command Decision display console for all information presented on the PPI. The OSC is similar to the OJ-194, with the following additional features: (1) track history memory, (2) ship's motion converter, (3) range bearing strobe and (4) large 20-inch CRT for group viewing.



1 COMMUNICATIONS PANEL
2 COMPUTER CONTROLLED ACTION ENTRY PANEL
3 6 X 7 PANEL
4 DIGITAL DISPLAY INDICATOR (IP-1304)
5 CRT CONTROL PANEL
6 DISPLAY CONTROL PANEL
7 SECURE VOICE CONTROLS
8 KEYBOARD (OPTIONAL)

Os310602

Figure 6-2.—OJ-194A(V)3/AN/UYA-4 PPI console control panels.

AN/UYQ-21 DISPLAY CONSOLE

The OJ-451(V)/UYQ-21 TDS display console (fig. 6-4) is the basic operator interface with the operational program. The TDS console can display symbology, graphics, and sensor sweep and video. It consists of the computer display console, a basic display unit (BDU), a TV monitor (CRO), and a communications station.

In addition to the PPI and its normal controls, the console displays symbology to completely and rapidly define the current tactical situation, and is a means of communicating data and orders to, and receiving processed information from, the computer program. Since there are several different versions of the TDS display console, refer to your ship's SOMs for operating instructions.

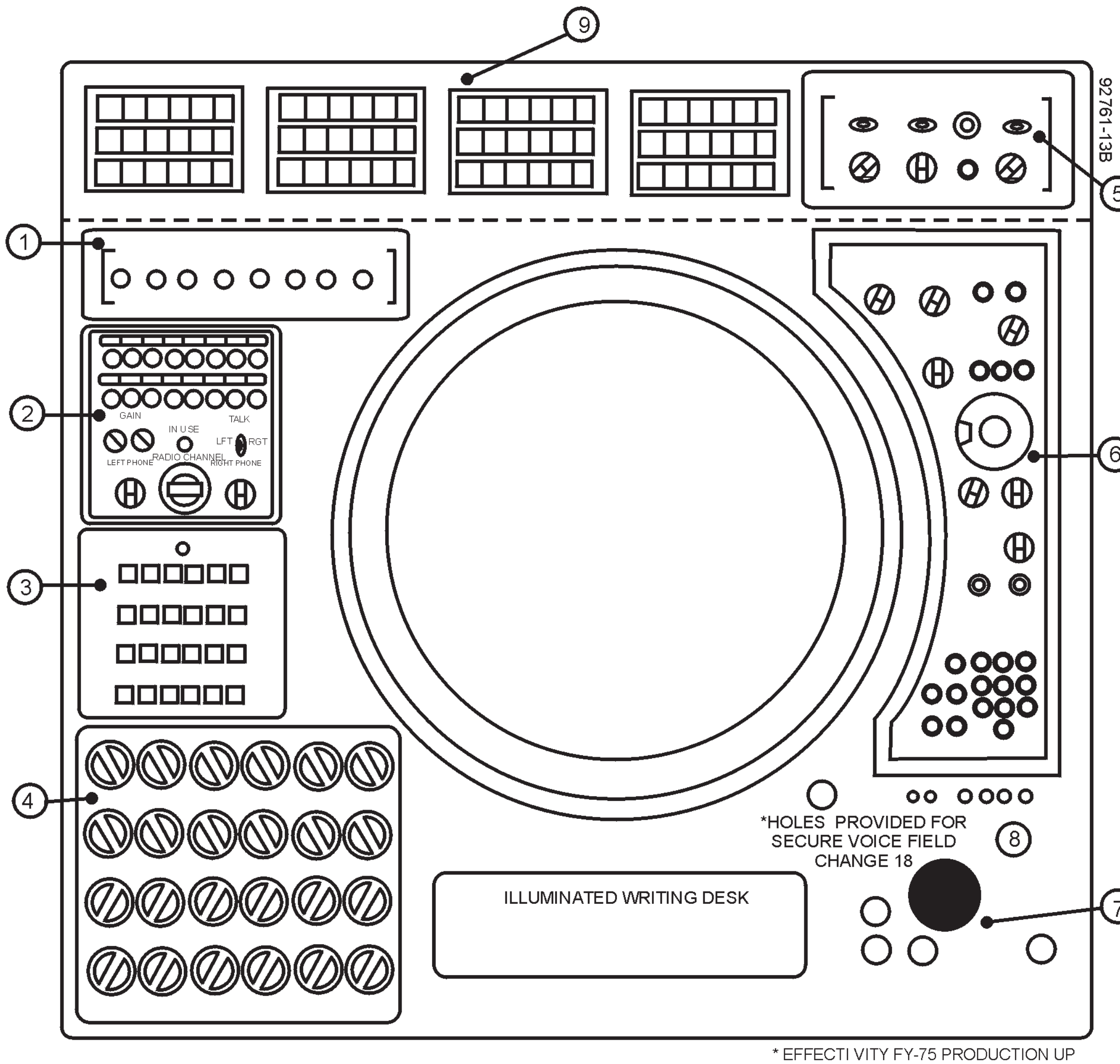
Q3. What are the two types of AN/UYA-4 consoles?

ANSWERS TO CHAPTER QUESTIONS

A1. The MASTER CLEAR switch.

A2. The GRAPHICS control switch.

A3. The OJ-194 and OJ-197 consoles.



1 CRT CONTROL PANEL
2 COMMUNICATIONS PANEL
3 COMPUTER CONTROLLED ACTION ENTRY
4 CATEGORY SELECT PANEL
5 DISPLAY CONTROL PANEL
6 SYMBOL - TRACK CONTROL PANEL
7 TRACK BALL CONTROLS
8 SECURE VOICE CONTROLS
9 AUXILIARY READOUT PANEL
10 (NOT ILLUSTRATED) A DDI-IP-1304 MAY BE INSTALLED ON TOP OF THE 9 AREA BY FC-24/OJ-197 AS AN OPTIONAL CONTRACT ITEM.

Figure 6-3.—OJ-197(V)/AN/UYA-4 Operations Summary Console Control Panels.

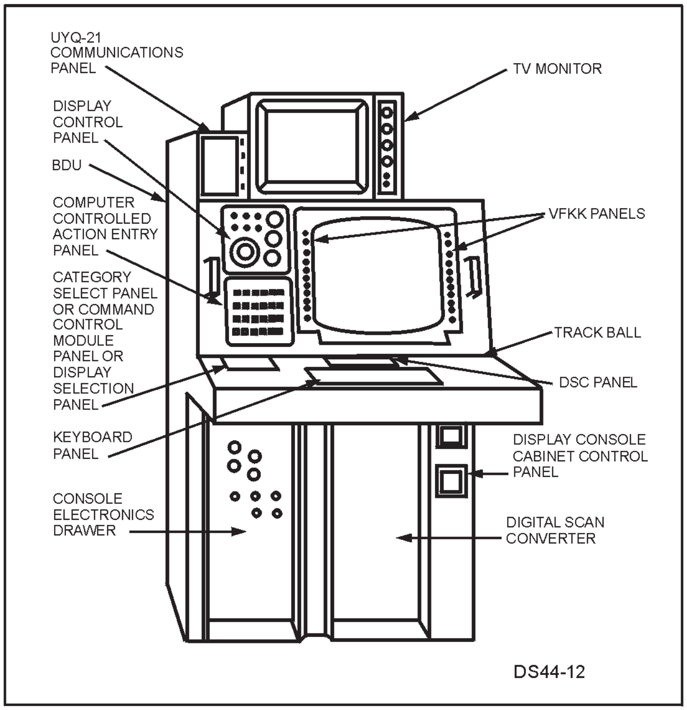


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Figure 6-4.—OJ-451(V)/UYQ-21 TDS display console.

CHAPTER 7

SCOPE INTERPRETATION

LEARNING OBJECTIVES

After you finish this chapter , you should be able to do the following:

1. Explain the four main PPI PIP characteristics.
2. Discuss two methods of tracking a contact on a radar scope.
3. Explain the techniques for identifying land, ship, and air contacts.
4. Recognize weather conditions on a radar scope.
5. Explain the various false contacts and other miscellaneous contacts.
6. Evaluate scope presentations.

INTRODUCTION

Scope interpretation is the studying of radar echoes for characteristics that will reveal the identification, character, and intent of targets. Target characteristics include the number of contacts (composition), bearing, range, altitude, course, and speed. Since the survival of the ship depends on its crew knowing the intent of nearby aircraft, accuracy in interpreting echoes is vital. As a member of the ship's early warning system, you should consider being able to perform in-depth scope interpretations as your primary fundamental skill.

The amount of reliable information that CIC can obtain from any radar depends, to a great extent, on the skill of the operator. An operator must have intelligence, imagination, skill, great concentration, and an intense interest in his work to provide maximum results. To become proficient, you must practice continually. The more you understand about the capabilities and limitations of your equipment, the better you will be able to apply your skill and knowledge to the tactical situation at hand.

You will often see strange looking contacts on the radar scope. Because their appearance is so difficult to describe, they are given names such as phantoms, pixies, gremlins, and the like. If you thoroughly understand the radar and know the positions of nearby ships, you should be able to recognize many types of false targets.

As you gain experience, you will notice many qualities in an echo that a less experienced operator will likely miss. Experience will enable you to judge more accurately the size and type of object causing an echo. For example, a skilled operator can usually distinguish the pip made by several planes in a group from the pip of a single plane. An unskilled operator, on the other hand, may be able to determine only the range and bearing. Even those may be unreliable at times. A proficient operator sees much more than just the position of a target.

A skilled operator can usually detect a target at a greater distance than an unskilled operator can. This ability results from his close observation of the scope and his "feeling" for the appearance of echoes that a less skilled operator might lose in the "grass."

A properly trained operator measures each range in exactly the same way so that his personal error is small and constant. As a result, these ranges and bearings are more consistent and reliable than those obtained by an unskilled operator. The skill you develop through constant practice will also enable you to measure ranges and bearing more quickly.

It is important that you recognize a target in the shortest possible time. Indecision creates costly delays, particularly if the target is a high-speed air

contact. Your speed in recognizing targets aids the plotters in assembling information, speeds evaluations and decisions, gives weapons personnel more time to react to a threat, and adds to the overall efficiency of the radar watch.

PPI PIP CHARACTERISTICS

There are four main pip characteristics you must consider in echo interpretation and evaluation. These are **shape**, **size, fluctuation,** and **motion**.

PIP SHAPE

The shape of a target pip on a PPI is very distinct. The use of a rotating beam makes this distinctness possible. As we discussed earlier, the target pip begins to appear when the edge of the lobe strikes the target. The pip strength gradually increases, reaching the maximum when the center of the beam is pointing directly at the target. The strength decreases as the remaining half of the beam moves across the target. Finally, after the beam has passed the target, the pip disappears. As a result, the pip presentation has a shape similar to that of a banana. For radars that do not use a rotating beam or display targets with computer-generated video, PIP shape probably will not change but PIP strength and size may vary, depending on the radar.

The pip is always displayed perpendicular to the PPI sweep. If you see a pip that is not at a right angle to the sweep, the pip is not a target echo. Dismiss it as a false target.

False targets are common. They can be caused by several types of interference, such as interference in the ship's power line, large variations in receiver noise level (static), interference from another radar operating in the same frequency band ("running rabbits"), atmospheric phenomena caused by electrical storms, and electronic jamming.

You will see ship and aircraft target echoes as sharp, well-defined pips. Land appears as a large, sometimes blotchy pip; while weather creates a very fuzzy or hazy pip. The quality of a pip is based on the amount of energy reflected back to the antenna by the target and how well the radar is tuned.

PIP SIZE

Earlier we discussed the effects that radar beamwidth and pulsewidth have on the size of a pip. We determined that the width of the pip is equal to the horizontal beamwidth of the radar plus the width of the target. Also, we said that the depth of the pip is equal to the minimum range of the radar (PW X 164 yards) plus the depth of the target. If a radar that has a horizontal beamwidth of 10° and a pulsewidth of 1 µs, every pip on the scope will be at least 10° wide and 164 yards deep.

Unfortunately, the PPI scope adds distortion to the depth of the pip. This distortion is the result of limitations in the minimum dimensions of each spot of light. Distortion is greatest on the longer range scales and almost nonexistent on shorter range scales. To minimize the effects of distortion, the range scale is seldom changed on repeaters that are used to search for or track targets. As a result, the long-range surface search operator becomes accustomed to a constant range environment discrepancy and knows exactly how much distortion to expect. The short-range surface search operator, on the other hand, will have very little distortion. Therefore, if each radar operator sets the repeater to a certain range scale, the distortion that a particular operator sees will be constant. The objective of this procedure is to ensure that the difference in size between the pips of two different targets is based upon the actual size of each target. For example, if an aircraft carrier and a destroyer are observed at about the same range, even an untrained operator can see that one pip is larger than the other. With more experience, you will be able to see the difference between the pips of an oiler and a destroyer.

A well-trained operator without the ability to make comparisons can still obtain a good estimate of target size. One of the best ways of judging the size of a target is to note the range at which it is first detected. At a given range, an object must be a certain size before it will return an echo that can be seen on the scope. In other words, the size of a ship or an aircraft determines when it will first become visible on the scope at a definite range. With aircraft, this initial pickup range will vary with the altitude of the aircraft (assuming that you and your equipment are operating at top efficiency).

You must also be aware that as ranges increase, you will have more difficulty in initially distinguishing between ship and land contacts. This problem occurs because a land target may initially appear as a single pip. As the range decreases, more and more pips appear in the same area. Finally, when the range is short enough, the number of pips is so great that they seem to merge into one solid, slightly distorted mass, having the general shape of a coastline, peninsula, or island.

On the other hand, when you initially detect a ship it will appear as a very weak pip. As the distance decreases, the pip will gradually become brighter. This increase in intensity is the result of echoes coming first from the ship's masts and superstructure and later from the ship's hull as well. The size of an echo will be about the same, regardless of the ship's course. However, as the range decreases or a change in course resulting in a beam aspect occurs, the ship will reflect increased amounts of energy and cause the pip shape and intensity to increase.

Echoes returned from air targets are generally smaller than those returned from ships. However, aircraft are usually detected at far greater ranges because of their altitude. An aircraft flying at 20,000 feet should be detectable at about 185 nautical miles by an air search radar. The pip seen for a single aircraft at long range is normally very weak.

Each radar has its own characteristic range at which a target of a certain type (air or surface) will appear. Because large ships generally have tall masts and superstructures, they will be detected at greater ranges than smaller, low-lying vessels, such as surfaced submarines and fishing boats. Once you learn the capabilities of a given radar, you will be able to estimate the approximate a target's size by its echo strength and range.

PIP FLUCTUATION

You can obtain valuable information by observing a target pip closely. Variation in signal strength can indicate the character of the target. These variations appear as changes in the brightness or size of the pip. Two aircraft flying together, for example, will usually produce a fluctuating pip. This happens because on one sweep of the radar beam a strong echo is returned from each aircraft. This causes a large, bright pip to appear. Then, possibly on the next sweep, an echo will be received from only one of the aircraft. This pip will be dimmer.

A change in target aspect can also cause a change in pip brightness. A single jet aircraft flying toward your ship presents a very small reflecting surface. The pip will be very weak or barely discernible. However, if the aircraft goes into a banking turn, it will display a larger reflecting surface and the pip will become much brighter. Consequently, you will usually observe a contact's change of direction long before the change is apparent on the plot. Whenever you observe a sudden change in the size of a pip, it indicates that the target has probably changed course.

Target Composition

You must watch every radar pip closely to obtain maximum information from its shape, movement, and size. Any variations from the normal—erratic fluctuations in brightness, abnormal size, or abnormal shape—will usually give you some indication of the number of targets contained in a pip. You should also be aware of the normal pip width and depth, which is based on the beamwidth and range resolution of the radar. If the pip is wider than the width you expect or deeper than the depth you expect, the echo is being returned from more than one contact. The presence of bumps on the top or sides of a pip may also indicate more than one target.

Fade Areas

Most radars have certain areas where contacts cannot be detected. These areas are predictable and are called *fade areas*.

As a radar transmits, some of the energy strikes the surface of the sea and is reflected upward. This upward traveling energy tends to have a cancellation effect at certain points on the energy traveling in a major lobe. This can result in many fade areas occurring within a radar lobe. Long-range air search radars have many large fade areas. These areas occur because of their lower frequencies. Higher frequency radars produce fewer and smaller fade areas. Figure 7-1 shows a fade chart for a typical air search radar. The figure illustrates a side view of a major lobe of the radar. The shaded portions are the fade areas. The radar will not detect an aircraft located in any of the fade areas.

Fade charts for all the radars installed aboard your ship are always available for your use. These charts provide valuable altitude information. Let's say you detect an air contact initially at 100 nautical miles. By referring to the fade chart in figure 7-1, you can see that the contact can be at any of several altitudes. However, if the aircraft maintains a constant altitude, it will fade and reappear at definite ranges. For purposes of illustration, assume that it fades at 40 nautical miles and reappears at 28 nautical miles. Entering the fade chart with this information, you can see that the aircraft's altitude is about 5,000 feet.

If the aircraft had been flying at a higher altitude, it would probably have been detected much sooner; however, its pattern would have been similar. Your skill

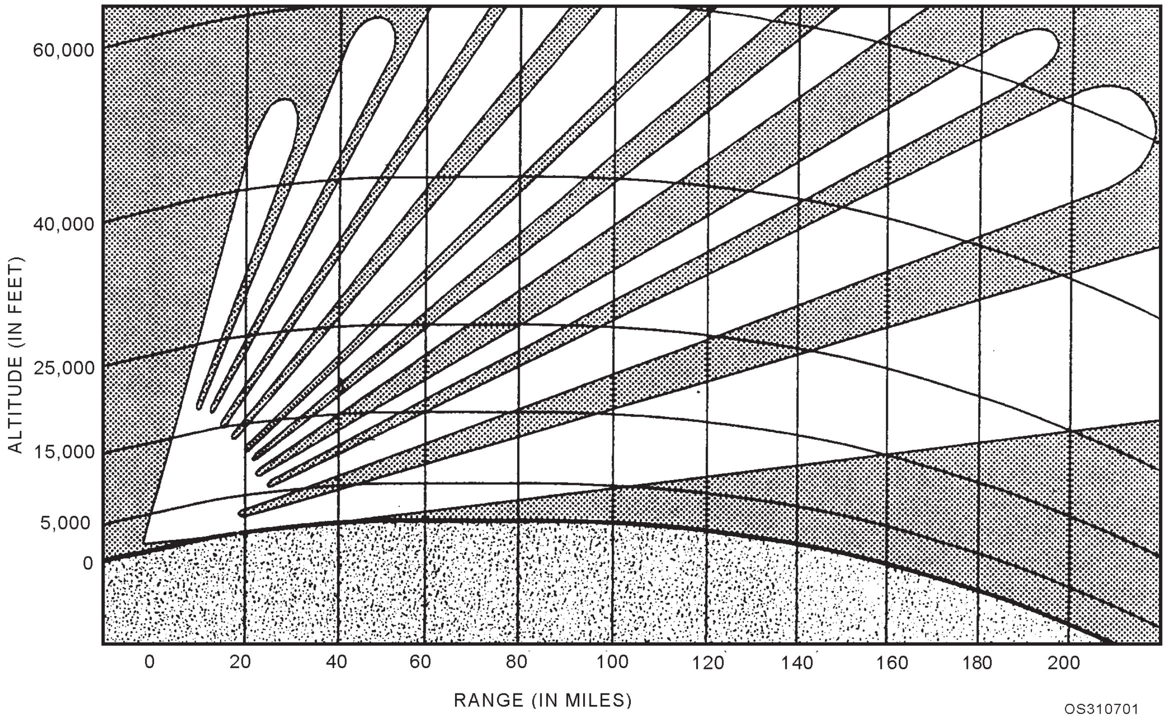

Figure 7-1.—Typical fade chart.

in using fade charts can serve you well when you are assigned to operate an air search radar—particularly if no height-finding radar is available.

PIP MOTION

The speed of movement tells you a lot about the probable nature of a target. An aircraft carrier can't make 100 knots, nor will most airplanes fly at 20 knots. The motion of a target often indicates that the target requires special attention. If an air contact is traveling at 1,800 knots, you should certainly give it more attention than you would give one traveling at 250 knots. Targets that you detect at short ranges, as well as those that will pass near your ship, also require your immediate attention. You must obtain as much information as rapidly as possible on any potential threat target to ensure that your ship will have sufficient time to react.

Your own ship's course and speed will affect the motion of surface contacts on a radarscope. During normal operations, the surface search operator has the PPI sweep fixed in the center of the scope, and all contact motion is relative to own ship's motion. If your ship is heading toward land, the range to the land will decrease at a rate equal to your ship's speed. Thus, you will see the land target moving toward the center of the scope at a speed equal to your ship's speed.

Now suppose your ship is heading east at 20 knots and another ship located 10 nautical miles due east of you is also heading east at 20 knots. The other ship will appear on the scope as a stationary pip 10 nautical miles to the east. As long as both ships maintain their course and speed, the pip will indicate no motion. However, if the contact decreases its speed from 20 knots to 15 knots while your speed remains at 20 knots, your ship will overtake the contact at the rate of 5 knots. At first, it appeared as though you were watching a stationary contact 10 nautical miles to the east. However, when the change in speed occurred, the contact suddenly started moving slowly toward the center of the scope. In other words, the contact appeared to be heading west at 5 knots.

Q1. What are the four main PIP characteristics?

Q2. Large fade areas are predominately associated with what type of radars?

INDICATOR TRACKING

A major problem that you may encounter is keeping an up-to-date reference on the locations and designations of targets. By using a reflector plotter and a grease pencil on a conventional radar repeater, you can keep this information accurately. By placing a series of marks on the face of the plotting device, you can establish a track on a target. There are two

recommended methods for marking a track—(1) the continuous line method and (2) the dot method.

CONTINUOUS LINE

The continuous line method consists of placing a grease pencil mark at the inside center of the pip and drawing back a short line. On each successive sweep, repeat your marking on the new pip. You must be sure to start at the new position of the target, then draw the line back and connect it with the last position. If you keep a sharp point on your grease pencil, you will produce a light, narrow, continuous line. This line will depict the track of the target clearly.

DOT METHOD

The dot method of tracking is the more widely used of the two methods. The procedure is very similar to that of the continuous line, except that you do not connect the positions of the target. As a result, the track will appear as a line of dots. The dot method has the distinct advantage of showing changes in the target's speed. A disadvantage is that course changes are less apparent than with the continuous line method.

EVALUATION OF SCOPE INDICATIONS

The indications that appear on a radarscope are quite varied. These indications include

1. natural targets (land, ships, and aircraft);
2. weather;
3. false targets; and
4. miscellaneous targets.

You, as the radar operator, will perform the initial evaluation of all targets.

HINTS ON IDENTIFYING NATURAL TARGETS

The primary types of natural targets are land, ships, and aircraft. Although there are other types of natural targets, a working knowledge of the primary types coupled with actual operating experience will enable you to evaluate all targets.

A well-trained CIC radar operator should never have trouble recognizing land targets. When you pick up a target, you should ensure that it is be plotted on a chart. This will help with final target evaluation.

Land Targets

You can usually identify objects as land targets by using the following information:

1. Land does NOT move on geographic plots; however, the it does move on the radarscope because of ownship's motion.
2. The pip usually remains at the same brightness.
3. Land will be at expected positions.
4. Land usually covers a greater area on the screen than other targets.
5. Separate pips caused by two land masses do not move relative to one another.
6. Sandspits and smooth, clear beaches do not show up on radar at ranges greater than a few nautical miles. The reason is that these targets have almost no area that will reflect energy back to the radar. Ranges determined from these targets are not reliable, because ranging may be to the surf rather than to the beach. If waves are breaking over a sandbar on the beach, echoes may be returned from the surf. Waves may break well out from the actual shore; therefore, ranging on the surf may be misleading when a radar position is being determined relative to the beach.
7. Mud flats and marshes normally reflect radar pulses only slightly better than sandspits do. The weak echoes received at low tide disappear at high tide. Mangroves and other thick growth may produce a strong echo. Areas that are indicated as swamps on a chart may, therefore, return either strong or weak echoes, depending on the density and size of the vegetation growing in that area.
8. When sand dunes are located well back from a low, smooth beach, the apparent shoreline appearing on radar is the line of dunes rather than the true shoreline.
9. Lagoons and inland lakes usually appear as blanks on a PPI scope because the smooth water surface reflects no energy to the radar antenna. In some instances, the sandbar or reef surrounding the lagoon may not appear on the radar either, because it lies too low in the water.
10. Coral atolls and long chains of islands may produce long lines of echoes when the radar beam is directed perpendicular to them. This is

especially true for islands that are closely spaced. The reason is that spreading, created by the radar's beamwidth, causes the echoes to blend into continuous lines. However, when the chain of islands is viewed lengthwise or obliquely, each island may produce a separate pip. Surf breaking on a reef around an atoll produces a ragged, variable line of echoes.

11. Submerged objects do not produce radar echoes. But, rocks projecting above the surface of the water, or waves breaking over a reef will appear on the radarscope. When an object is entirely submerged and the sea is smooth, you will see no indication on the scope.

12. If land rises gradually from the shoreline, no part of the terrain will produce an echo that is stronger than the echo from any other part. As a result, a general haze of signals will appear on the scope. This makes it difficult to determine the range to any particular part of the land. In fact, if the antenna is held still and the ship is not rolling, the apparent range to a shore of this sort may vary as much as 1,000 yards. This variation may be caused by slight changes in propagation conditions, which cause the beam to be moved up and down the slope.

As mentioned above, you can recognize land by plotting the contact. You must use care, though, because as a ship approaches or goes away from a shore behind which the land rises gradually, a plot of the ranges and bearings may indicate an apparent course and speed. You can understand this situation by referring to figure 7-2. In view A, the ship is 50 nautical miles from the land, but because the radar beam strikes at point 1, well up on the slope, the indicated range is 60 nautical miles. Later, in view B, when the ship has moved 10 nautical miles closer to land, the indicated range is 46 nautical miles because the radar echo is now returned from point 2. In view C, when the ship has moved another 10 nautical miles, the radar beam strikes even lower on the slope. Now the indicated range is 32 nautical miles. If you plot these ranges, the land appears to be coming toward the ship at a speed of 8 knots, as shown in view D.

In the illustration, we assumed the land mass to have a smooth, gradual slope so that we could obtain a consistent plot. In practice, however, the slope of the ground is usually irregular and the plot erratic. This makes it hard to assign a definite speed to the land contact. The steeper the slope of the land, the less its apparent speed. Furthermore, since the slope of the

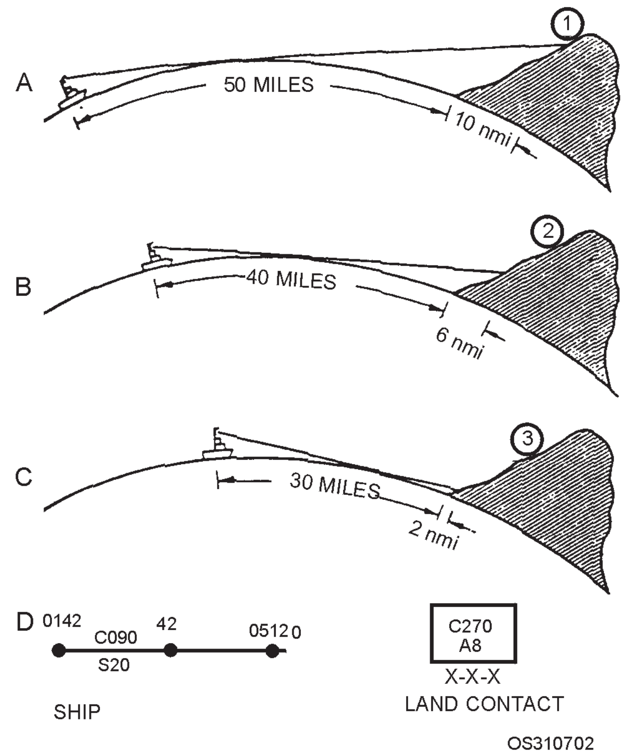

Figure 7-2.—Ship approaching land that rises back of shoreline.

land may not fall off in the direction toward which the ship is approaching, the apparent course of the contact will not be opposite the course of the ship, as we assumed in this simple illustration.

13. Blotchy signals are returned from hilly ground because the crest of each hill returns a good echo while the valley beyond it is in a shadow. If you use high receiver gain, the pattern may become solid except for the very deep valleys.

14. Low islands ordinarily produce small echoes. However, when thick palm trees or other foliage grows on the island, strong echoes are often produced, because the horizontal surface of the water around the island forms a sort of corner reflector with the vertical surfaces of the trees. As a result, wooded islands give good echoes and can be detected at much greater ranges than barren islands.

Ship Targets

You will spend the majority of your time on watch searching out and tracking surface contacts.

You will learn to recognize a ship partly by a process of elimination. Here is an example of how this method works: First a small echo appears. A check of

the target's position shows no land in that sector. Also, the echo does not have the usual massive appearance that characterizes both land and cloud echoes. You rule out aircraft because the target appears relatively stationary. Finally, the appearance of the pip clinches it. A steel ship is an excellent reflecting surface. The echo at a medium range is bright, clearly defined, and steady.

By knowing your radar and understanding how various ships appear on your scope, you can make a good estimate of the size and type of ship. Familiarity with the radar set will help you determine the maximum ranges at which you can expect to detect different types of ship targets. A target that first appears on a typical radar set at 20 nautical miles is likely to be a destroyer or similar ship. Something showing up at 10 nautical miles is likely to be a fishing boat, surfaced submarine, or other low-lying vessel. You also know that large ships will appear at greater ranges. You can improve your judgment regarding the nature of the ship considerably by knowing what is likely to be in the area.

You will detect a formation of ships at greater distances than you will a single ship because a group of ships has a larger reflecting area. At a great distance, the formation appears as a single, large target. You may mistake it for a small island. As the range closes on a formation, you will be able to distinguish individual ships. Within a range of 10 nautical miles, you will be able to determine the number of ships and their positions within the formation by the number, position, and bearing of the echoes. You can recognize the general types of ships by the appearance and strength of the echoes. Other characteristics of ship targets are:

1. The pips slowly increase and decrease in brightness.
2. Normally, there are no fade zones except at long ranges.
3. Speed is less than 50 knots.
4. Small craft or fishing boats appear at about 8 or 10 nautical miles and appear as extremely weak echoes. Plotting these contacts indicates they are moving at slow speeds.

Air Targets

The easiest way to identify an aircraft is to observe the motion of its echo on the radarscope. The echo from an aircraft will appear much the same as an echo from a small ship. However, the aircraft's echo will show rapid motion.

Another indication that a pip represents an aircraft is that the echo fades and soon reappears. This characteristic is typical of any small, weak target, but is more common with aircraft because of fade zones.

Aircraft change their aspect more rapidly than other types of targets do. Consequently, aircraft echo intensities fluctuate more rapidly than those from other types of targets. The normal echo of an aircraft on the PPI scope varies rapidly in brightness.

Helicopters are often mistaken for ships. The best recognition method is observing the speed at which the helicopters move—faster than ships but slower than fixed-wing aircraft.

Q3. Why do sandspits and smooth beaches produce a radar return that can be detected only a few miles?

Q4. How can you determine if a radar pip on your scope is a ship?

STORMS AND CLOUDS (WEATHER)

Sometimes radar is used to observe weather by detecting rain squalls, clouds, and regions of sharp temperature contrasts. Different types of weather produce various returns on the scope. For the scope to detect weather, some form of precipitation must be present—rain, snow, hail, mist, or heavy fog. Higher frequency radars give the best indication. If the precipitation is heavy enough, you may not be able to see through it on certain radars. Usually the edges of weather echoes appear fuzzy on the PPI scope.

COLD FRONTS

One of the more common weather returns is produced by a squall line accompanying a cold front. The squall line may precede the actual front by only a few nautical miles or by as much as 200 nautical miles. The line is usually well defined and quite narrow. (See figure 7-3.) Thunderstorm activity is severe in most squalls. If you are alert, you can locate severe and less active areas. If the line is solid, lowering the gain will leave only the more intense and most active areas on the scope.

WARM FRONTS

Warm fronts are usually accompanied by steady, moderate rain and an occasional thunderstorm. Their

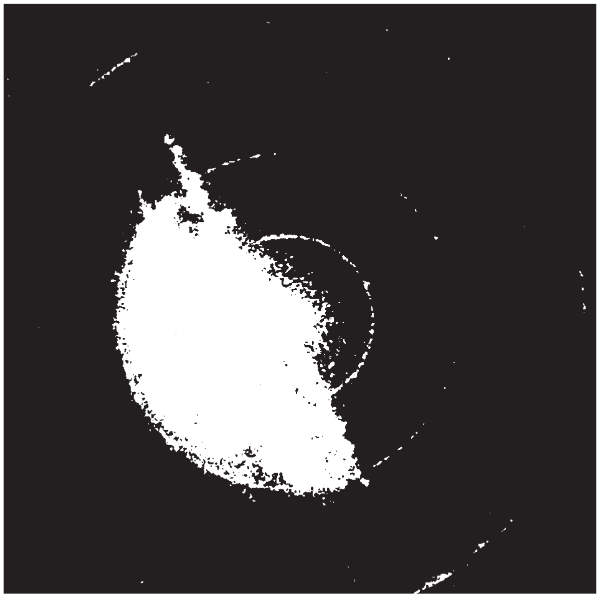

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Figure 7-3.—Cold front.

appearance on a radar is different from that of a cold front. They are much thicker and normally give a steady, solid return as opposed to groups of returns. If thunderstorm activity is present, you may locate it by reducing the gain until only the area of strongest return remains on the scope. Figure 7-4 shows a typical warm front. Compare it with the cold front in figure 7-3.

HURRICANES AND TYPHOONS

Hurricanes and typhoons are dreaded weather phenomena. These storms may produce extremely high winds, which in turn produce very rough seas. Each hurricane has unique characteristics but, from studies of these storms, we can state some general rules. The average range of detection is about 200 to 250 nautical miles. The first indication on the scope is quite similar in appearance to that of a warm front. As the storm approaches, echoes from the precipitation show spiral or circular bands which grow increasingly smaller as they near the center of the storm. The rain and accompanying winds are more severe in this area. Heavy thunderstorms and hail may also be present around the outer limits of hurricanes.

If you detect a hurricane, report its position immediately. Weather-tracking aircraft, land-based radars, and satellites are always searching for these storms during storm season.

Information on these storms is vital to the safety of shipping and coastal areas. Figure 7-5 shows a hurricane as it appears on a PPI scope.

TORNADOES AND WATERSPOUTS

Tornadoes are extremely violent storms that form over land. Waterspouts resemble tornadoes but form over water and cause very little, if any, destruction.

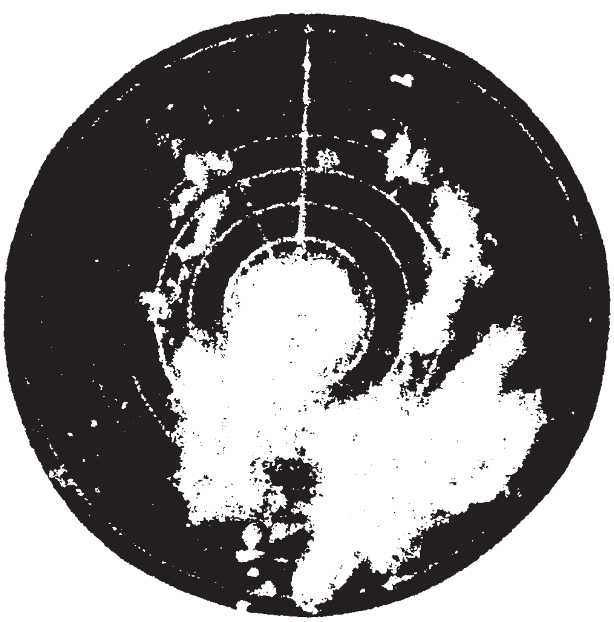

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Figure 7-4.—Warm front.

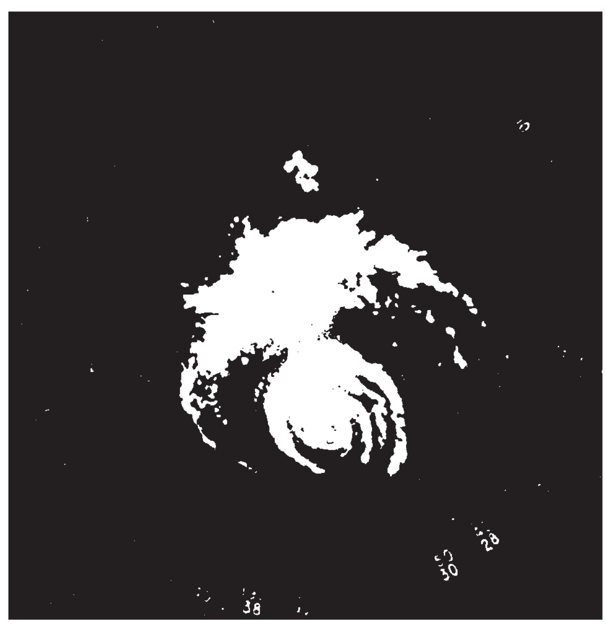

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Figure 7-5.—Hurricane (PPI scale 200 nm).

Although the exact cause of tornadoes is unknown, they appear during certain meteorological conditions and seem to move in a distinct pattern. Most tornadoes move in a northeasterly direction at a forward speed of up to about 45 knots.

On the PPI scope, a tornado or waterspout appears to be V- or hook-shaped. A very small eye or blank spot at the center is a general indication of its existence.

FALSE OR PHANTOM CONTACTS

Many pips that appear on radarscopes look like echoes given off by aircraft or ships do not, in fact, represent aircraft or ships. You need to learn what causes these pips and how they look so you can recognize them instantly.

Radar contacts made on targets that cannot be seen are often given the erroneous title “phantom” contacts. Actually, clouds, turbulence, birds, fish, weather conditions, or wakes may cause them. All of these phenomena reflect radar pulses to some extent. In general, an alert operator can recognize echoes from these sources.

MINOR LOBES

The beam of waves sent out by a radar is not shaped as perfectly as the beam of a searchlight. Actually, it appears similar to the beam shown in figure 7-6.

The main (or major) lobe radiates in the direction in which the antenna is pointing. A series of smaller lobes (unwanted but unavoidable) point in various other directions. When these minor lobes (called side lobes and back lobes) point at an object, they produce echoes if the object is large and nearby.

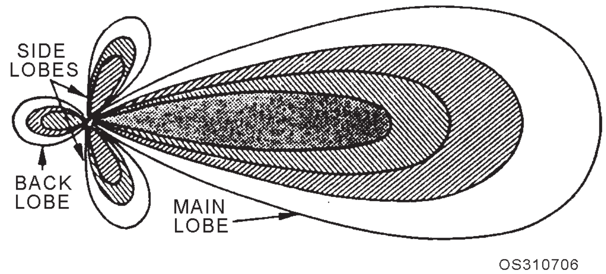


Figure 7-6.—Major (main) and minor (back and side) lobes.

Because the sweep is synchronized with the major lobe, all return will appear to be from that lobe. You can recognize minor lobe returns by their size and the fact that they are at the same range as the major lobe return. Sometimes the minor lobe returns are present through 360° of bearing. This makes it difficult to obtain an accurate bearing on the true contact. When you reduce the gain, minor lobe returns will usually disappear, leaving only the major lobe return. Some newer radars have a side lobe suppressing circuit that you may use to eliminate these undesirable minor lobe echoes.

DOUBLE ECHOES

You will detect double echoes most frequently when a large target is close aboard and on the beam. Such echoes are produced when the reflected beam is strong enough to make a second or third round trip, as shown in figure 7-7. Double echoes are weaker than main echoes and appear at twice the range. Triple echoes are usually so weak that they are seldom seen. Double echoes can be deceiving. If you do not recognize them instantly, you might make the mistake of reporting them as a submarine periscope contact. Used correctly, they can be useful. For example, they can indicate whether your radar is in calibration. The

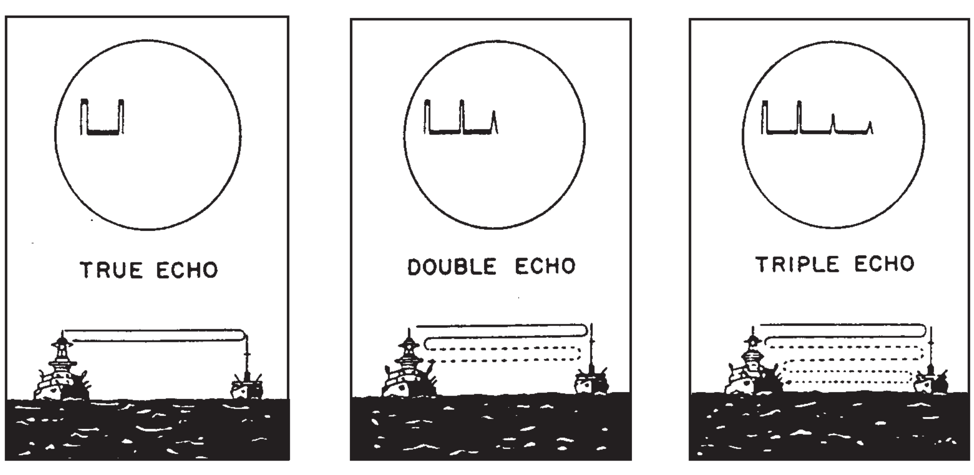


Figure 7-7.—Multiple-range echoes.

range from your ship to the target should be the same as that from the target to the second echo. One of the fleet exercises conducted aboard your ship will consist of setting up an optimum condition. The objective is to obtain these echoes for purposes of calibrating the radar.

SECOND-SWEEP ECHOES

Second-sweep echoes, seen occasionally on the scope, are returned from targets beyond the maximum theoretical range of the radar. Let's say you are operating a radar that has a maximum theoretical range of 125 nautical miles. A mountain 135 nautical miles away would be presented on the PPI at an apparent range of 10 nautical miles. This 10 nautical miles is the difference between the actual range of the mountain and the maximum range of the radar. This happens because each transmitter pulse starts the repeater timing. If the radar transmits a second pulse before an echo is returned from the previous pulse, the echo is presented in relation to the second pulse. When the PRR of the radar is varied, the apparent range of the second-sweep echo changes. Using the previous example, the maximum theoretical range of the radar is 125 nautical miles, and a target at 135 nautical miles is presented at 10 nautical miles. If the PRR is increased to the point where the maximum theoretical range becomes 120 nautical miles, the range to the second-sweep echo will increase to 15 nautical miles. Conversely, if the PRR is decreased in order to increase the maximum theoretical range to 130 nautical miles, the second-sweep echo will jump to 5 nautical miles. Varying the PRR allows you to recognize second sweep echoes immediately. The range to a true target will not vary when the PRR is changed.

RADAR INTERFERENCE

Often, you will see one or several lines that move rapidly across the screen. These lines are usually caused by another radar transmitter operating on or near your radar's frequency. They are called "running rabbits" because of their unusual appearance on the scope.

MISCELLANEOUS CONTACTS

At close range you may get some other false echoes that seem unaccountable. They may be from whitecaps (beyond sea return in the direction from which the wind is coming), from birds, or from such floating objects as large tin cans, powder cases, or even seaweed.

As a rule, echoes from birds or flying fish are faint. In addition, the behavior of birds is usually different from any other type of airborne target. Continued observation of the movement of the echoes should reveal them as birds. Because birds and fish are relatively small, they return echoes only at short ranges. A visual check by lookouts or other topside personnel will help you determine the cause of these targets.

WAKES

Occasionally, the radar will pick up reflections from the wake produced by a nearby large ship, especially during turns and high-speed running. Pips from wakes are small, have poor definition on the PPI, and are near to and astern of the echo of the ship causing them.

ATMOSPHERIC NOISE

The frequencies used by radar are so high that atmospheric noise or static has little effect on radar operation. The noise showing on an indicator is normally produced in the early stages of the receiver. Other strong pulses, similar to noise pulses, have been observed on some radar indicators as the result of nearby lightning flashes. A-band radars will sometimes encounter serious interference from St. Elmo's fire (basically, static electricity). The aurora borealis (northern lights), which interferes tremendously with most communications, has no apparent effect on radar.

Q5. What is the main cause of a contact producing a double echo?

ANALYZING DISPLAYS

Indicator presentations can be difficult to analyze. Although problems may arise on any type of target, you will encounter the greatest difficulties with land displays. When a ship operates close to land, CIC must maintain an up-to-date plot to assist in navigation. This requires a sufficient number of points of reference to establish a position. Fade zones and distortion also make identifying sufficient references difficult.

A straight shoreline often looks crescent-shaped on the PPI. This effect can be seen on any radar occasionally, but it is most pronounced on air search radar. The crescent-shaped effect is caused by

beamwidth distortion. The wider the beamwidth, the greater the distortion.

Shoreline distortion is negligible at points where the shore is at right angles to your antenna. But, as the angle decreases, the shoreline distortion increases.

SIDE LOBE RINGING

At times, the crescent-shaped effect is so pronounced that when you look at the PPI, you seem to be in a land-locked harbor or lagoon. Actually, you are standing off a straight shoreline. This complete ringing effect appears mostly on air search radar. It is confusing to air intercept controllers and others concerned with controlling aircraft. Side lobe ringing is the result of a combination of beamwidth distortion and side and back lobes.

LOW LAND

Radar frequently fails to detect low-lying and gradually sloping land, especially at long range. This effect results in another distortion of the coastline.

SHIPS NEAR SHORE

Ships, rocks, and other targets close to shore may blend in with the shoreline. This mixture is caused by the spreading effect of all targets, both in range and bearing, due to the beam and pulsewidths of the radar.

SUMMARY OF DISTORTIONS

The various distortions we have been discussing are summarized in figure 7-8. View A shows the actual shape of the shoreline and the land behind it. Notice the radio tower on the low sandy beach, the two ships at anchor close to shore, and the lighthouse. The heavy line in view B shows how the land looks on the PPI. The dotted lines represent the actual position and the shape of all targets. Notice in particular the following conditions:

1. The low sandy beach is not normally detected by the radar.
2. The tower on the low beach is detected, but it looks like a ship in a cove. At closer range, the land would be detected and the cove-shaped area would begin to fill in; then, the radio tower could not be seen without reducing receiver gain.
3. The radar shadow behind both mountains increases. Distortion due to radar shadows is responsible for more confusion than is caused by any other condition. Radar-shadow distortion prevents the small island from showing.
4. The land spreads in bearing because of beamwidth distortion. Look at the upper shore of the peninsula. The shoreline distortion is greater to the west because the angle between the radar beam and the shore is smaller as the beam seeks out the more westerly shore.
5. Ship No. 1 appears as a small peninsula. The contact has merged with the land because of beamwidth distortion. If the land had been a much better target than the ship, the ship would have been wiped out completely.

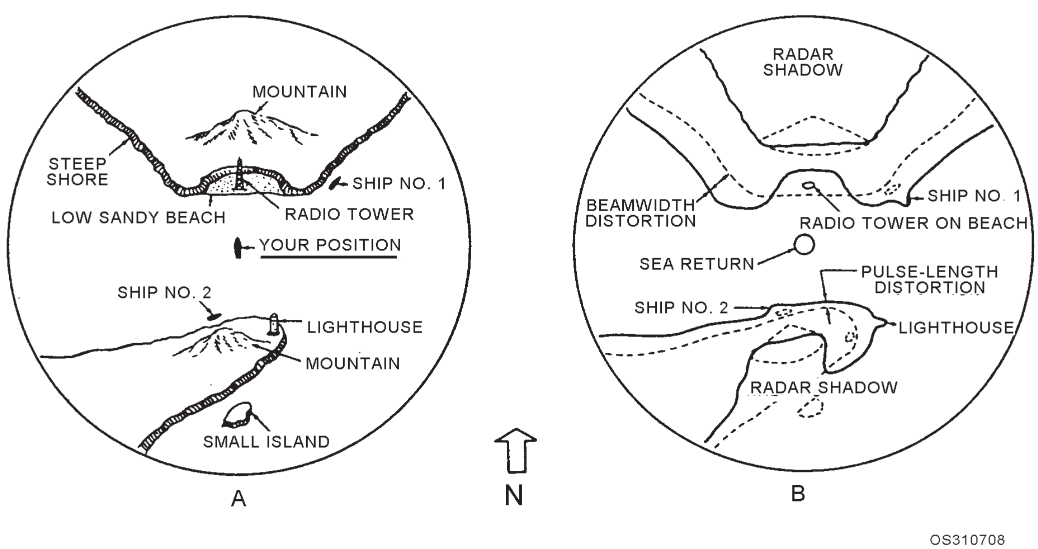


Figure 7-8.—The effect of beamwidth distortion and pulse-length distortion.

6. Ship No. 2 also merges with the shoreline and forms a bump. This display is caused by pulse-length distortion. Reducing receiver gain might cause the ship to separate from the land, provided it is not too close to the shore.
7. The lighthouse also looks like a peninsula because of beamwidth distortion.

Q6. What causes the radar return of a ship near the shoreline to blend in with the land return?

SCOPE EVALUATIONS

Surface search presentations are relatively easy to evaluate. Figure 7-9 shows a photograph of a surface search radarscope taken during a snowstorm. You can see the falling snow to the west, southwest, and south. The northern part of the scope is covered with land return. There are several surface contacts present to the east, northeast, and northwest. Note the surface contact partially merged with the snow at 160°. (Range rings are 1 mile apart.) Your ship appears to be heading 085° because the blank area at 265° is probably a stern shadow caused by a mast or other structure on the ship.

Evaluating air search radar presentations can be a little more difficult. Figure 7-10 shows an air search radarscope with the range rings 10 nautical miles apart. Let's discuss each contact individually.

1. The pips northwest at about 20 nautical miles appear to be two aircraft.

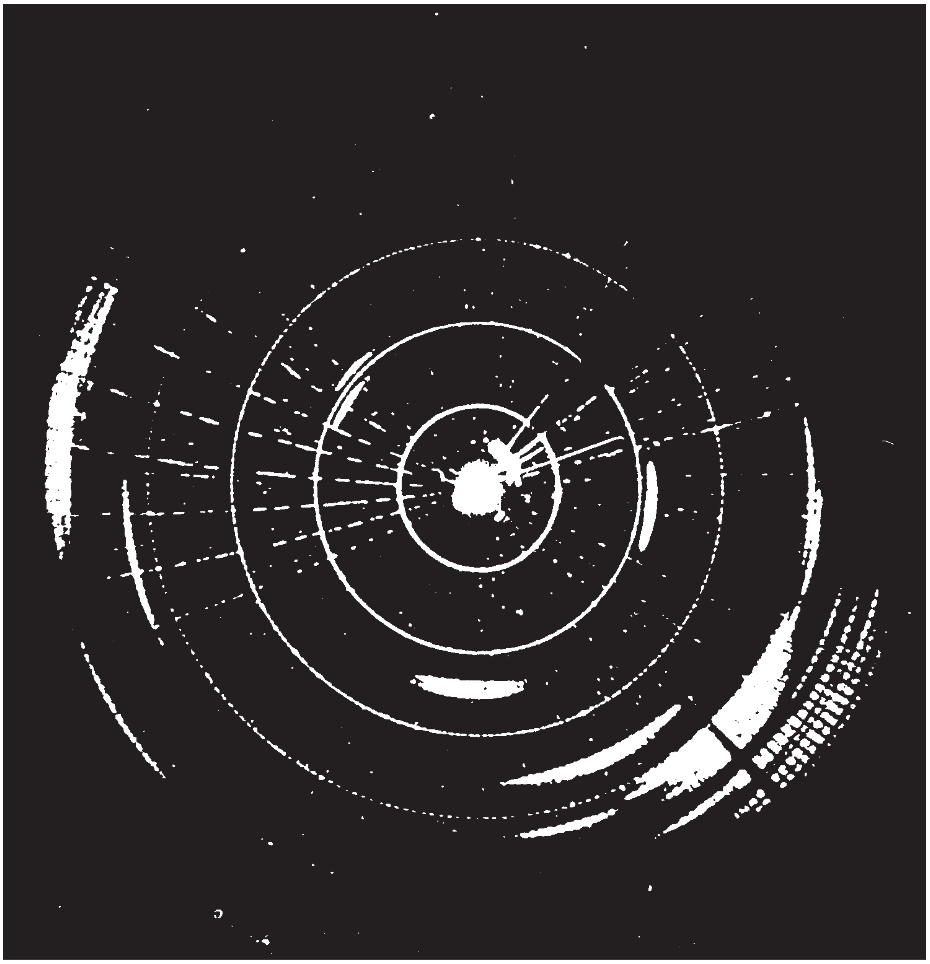
OS310709

Figure 7-9.—Land, surface contacts, and a snowstorm on a PPI.

2. The pip northeast at 5 nautical miles is very large and is probably more than one aircraft. It may be a ship.
3. The pip to the east at 21 nautical miles is probably two or more aircraft flying close together.
4. The pip to the south at 24 nautical miles appears to be two aircraft because two separate pips are distinguishable.
5. The pip to the west at 42 nautical miles appears to be a single aircraft.
6. The pip to the southwest at 51 nautical miles is probably a minor lobe echo from the land to the west.
7. Another large land area can be seen to the southeast. The pips in that vicinity are either land echoes or minor lobe echoes from the land.

Figure 7-11 shows the same radar, the same scope, with the same range scale setting, taken about 30 seconds later. Let's see how good our evaluations were.

1. The pips northwest at about 20 nautical miles have weakened considerably. It will be necessary to wait at least another sweep for a good evaluation.
2. The pip northeast at about 5 nautical miles is now spreading out and certainly is at least two aircraft.
3. The pip to the east at 24 nautical miles appears to be two aircraft because of the two separate bumps.
4. The pips to the south have separated and are definitely two aircraft, one heading north and one heading south.
5. The pip to the west at 44 nautical miles is an aircraft heading west.
6. The pip to the southwest at 53 nautical miles is an aircraft rather than a minor lobe echo, because it has moved 2 nautical miles in 30 seconds.
7. The pip at 159°, 40 nautical miles is an aircraft rather than a minor lobe echo. Refer back to figure 7-10. You can see this same contact at 163°, 42 nautical miles. The contact is definitely an aircraft heading northeast.



OS310710

Figure 7-10.—Air search radar presentation.

8. A new pip has appeared to the northeast at 50 nautical miles. It could be an aircraft or a minor lobe echo. We will have to wait at least one more sweep to be sure.
9. Another new pip has appeared to the northeast at 30 nautical miles. This contact is probably an aircraft that was in a fade zone on the previous sweep. The possibility of its being a minor lobe echo is eliminated because minor lobe echoes are always presented at the same range as the land target that produces them. Since there is no land on the scope at 30 nautical miles, this pip cannot be a minor lobe echo.

Notice the lines of interference to the west and northeast. These are probably caused by interference from other friendly radars in the area operating in the same frequency range.

The more you operate or stand watch on the scopes, the more proficient you will become. This skill, in turn, saves time in your evaluation of what appears on your scope.

You know now, for instance, that radar shadows exist behind objects that reflect radar energy. If the antenna for your radar is not mounted higher than everything else on the ship, a blind sector may exist. Such objects as masts, superstructures, and other antennas can cause radar blind sectors. Most ships have prepared charts showing the blind sectors. Know the blind sectors on the radar you are operating.

ANSWERS TO CHAPTER QUESTIONS

A1. Shape, Size, Fluctuation, and Motion.

A2. Low frequency radars.

A3. These targets have almost no area that will reflect energy back to the radar. Ranges determined from these targets are not reliable, because ranging may be to the surf rather than to the beach.

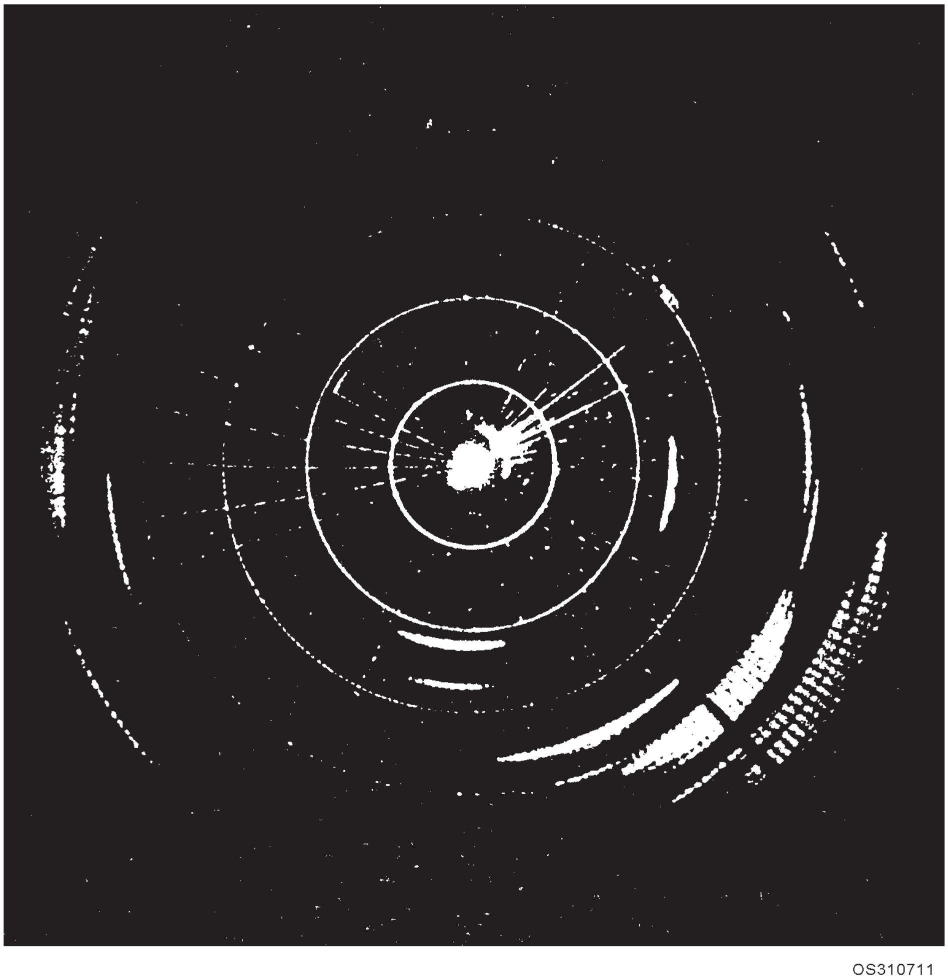


Figure 7-11.—Air search presentation 30 seconds later.

A4. By a process of elimination. First, check the navigational position for the possibility of land in that sector. Next, if the target appears relatively stationary, rule out aircraft. Finally, look at the appearance of the pip. A steel ship is an excellent reflecting surface. The echo at a medium range is bright, clearly defined, and steady.

A5. A large target is close aboard and on the beam. Such echoes are produced when the reflected beam is strong enough to make a second or third round trip.

A6. The spreading effect of all targets, both in range and bearing, due to the beam and pulse widths of the radar.

CHAPTER 8

IDENTIFICATION EQUIPMENT

LEARNING OBJECTIVES

After you finish this chapter , you should be able to do the following:

1. Describe a basic IFF system and how it operates.
2. Identify the AIMS MK XII IFF system components and explain their operation.
3. Explain the use of the AIMS MK XII equipment in a jamming environment and in emergency (Mode 4) operations.

INTRODUCTION

Identification Friend or Foe (IFF) is the system that ships and stations use to identify friendly aircraft and ships. Since hostile aircraft, with their fast speeds, pose a greater threat than ships, we will concentrate on aircraft IFF procedures. However, some of the IFF procedures also can be used for identifying ships. Basically, the ship or station desiring to know whether an approaching aircraft is friendly sends out a special electronic signal in the direction of the aircraft. The signal triggers an electronic response from an IFF transmitter in friendly aircraft. This response signal, in turn, generates a coded symbol on the radar scope of the interrogating ship or station. This symbol, in addition to designating the contact as friendly, may provide such information as type of craft, squadron, side number, mission, course, and altitude. If the aircraft does not respond, it is classified as either "unknown" or "hostile".

IFF evolved in World War II, with each service developing its own equipment for its own particular requirements. This resulted in a variety of miscellaneous, specialized equipment with little or no interchangeability.

In 1963, the U.S. Armed Forces pooled their requirements and efforts under an Air Force project office and created a set of requirements for a new IFF system, designated AIMS. AIMS, an acronym of acronyms, stands for:

ATCRBS	Air Traffic Control Radar Beacon System
IFF	Identification Friend or Foe
MK XII	Mark XII
S	System

Today, all U.S. armed forces use the AIMS (Mark XII IFF) system, primarily to identify friendly units rapidly and positively. They also use AIMS for tracking and controlling aircraft. In the military world, high-speed aircraft present a critical problem in detection, identification, tracking, and evaluation. Time is extremely critical when aircraft are approaching at Mach (speed of sound) speeds. To provide ample time for initiating appropriate action, a ship must be able to detect and identify aircraft at the greatest possible distance. In operations involving friendly ships and aircraft, it is important to know not only the location but also the identity of each craft. For these reasons, all of the armed services use IFF equipment in conjunction with search radars.

In the civilian world, the increased numbers and speed of commercial aircraft (both domestic and international) presented problems for air traffic controllers. To overcome these problems, civilian authorities worldwide adapted IFF for civilian air traffic control. In the civil air traffic control environment, IFF is called Secondary Surveillance Radar (SSR).

IFF systems operate in one or more *modes*. A mode is the electronic method used to identify an aircraft and to display information about the aircraft on a radar

scope. A basic mode consists of one or two tones to indicate a friendly aircraft. Advanced modes add codes to the tone(s) to provide additional information about the aircraft. Civilian SSR systems operate in four modes designated as “A”, “B”, “C”, and “D”. Military IFF systems use four modes of operation, identified as mode 1 through mode 4.

The basic SSR (civilian) mode is mode A, which is essentially identical to the military mode 3; therefore, this mode is commonly referred to as mode 3/A. Mode B has very limited use and has no military equivalent. Mode C is reserved for automatic pressure altitude transmission and has been adopted for both civil and military altitude reporting. Mode D has not been established internationally.

Military modes 1, 2, and 4 have no civilian equivalent. Mode 1 is known as the general identification or mission signal and is used as directed by area commander instructions. Mode 2 provides the personal identification (PI) code for a specific airframe or ship; these codes are assigned by area commander notices. Mode 3/A uses codes for air traffic control within the Continental United States (CONUS) and for other purposes as directed by the operational command outside CONUS. It may be used in conjunction with “IFF Mark XII Mode 3/A Safe Passage Procedures” (AKAA 283 and 285 series). Mode 4 is used only to verify friendly status.

Since IFF/SSR is used internationally, you must be aware of the types of IFF systems used by friendly nations. Some countries use the Mark XII IFF, while others use the Mark X IFF. The Mark X system is available in three versions—basic Mark X, Mark X (SIF), and Mark X (A).

Basic IFF Mark X is the oldest IFF system still used by friendly nations. It can reply by mode only (codes are not available from the transponder). The basic reply for modes 1 and 3 is a single pulse. The response for mode 2 is two pulses spaced 16 microseconds (μs) apart. IDENT (I/P) and emergency feature are available. A low-receiver-sensitivity function is also available.

IFF Mark X (SIF) has a selective identification feature (SIF), which adds reply pulse coding to the basic IFF Mark X system, allowing operators to identify, track, and control friendly aircraft. The SIF was added to basic IFF Mark X because the system had low inherent security and did not allow operators to identify individual friendly aircraft The number of codes available is 32 in mode 1; 4,096 in mode 2; and 64 in mode 3. IDENT (I/P) and emergency features are also available.

IFF Mark X (A) is essentially the same as IFF Mark X (SIF) except that mode 3 provides 4096 codes has the SSR mode C added.

AIMS (IFF Mark XII) equipment is compatible with IFF Mark X (SIF) and IFF Mark X (A). In addition to operating in IFF Mark X modes 1 through 3, Mark XII equipment can also operate in mode 4. Mode 4 adds communications security equipment to the IFF system. AIMS equipment can also operate in mode C, which provides for automatic pressure altitude reporting.The AIMS equipment is capable of supporting diverse missions, such as surface warfare (SUW) and air warfare (AW), aerial and naval bombardment, and aerial and naval attack. It permits friendly forces to recognize each other and to distinguish themselves from neutral or hostile forces. The system also can serve as an auxiliary surveillance radar to assist in tracking friendly forces when the primary radar is obscured by clutter.

For detailed information on operations policy and SIF code assignments, refer to the classified documents listed in the references section at the end of this manual in Appendix I.

IFF SYSTEM OVERVIEW

A basic IFF system consists of an interrogator subsystem and a transponder subsystem. The interrogator transmits challenges (also called interrogations) on a frequency of 1,030 MHz. When a transponder on another craft receives a valid interrogation, it transmits (on 1,090 MHz) a response that designates the craft as friendly and may, depending on the system, also identify the craft. The interrogator receives the response and processes it for presentation on a radar scope. The interrogator subsystem is normally associated with a search or fire control radar and is called a “slaved” system. IFF interrogations are synchronized with the radar transmissions, with the interrogator pulse repetition frequency (PRF) usually equal to the radar PRF or a sub-multiple of it. The interrogations are transmitted slightly before radar zero-range time, allowing transponder replies to fall near the associated radar targets on a radar display console.

Interrogator subsystems that are not associated with a radar are called “black IFF” systems. For black IFF systems, the timing is usually adjusted so that target replies fall at the true target range and azimuth

on the display unit (plan position indicator (PPI)). Radar targets are not displayed with black IFF video. IFF interrogations are transmitted on a rotating directional antenna (usually mounted atop or as an integral element of a search radar antenna), and transponder replies are received on this same antenna. Transponders receive interrogations and transmit replies on an omnidirectional antenna.

A ship may be equipped with one or more interrogator subsystems, but only one transponder subsystem. In general, interrogators and transponders work independently of each other. The only interconnection between the two is a suppression signal to inhibit the ship's transponder from replying to the ship's own interrogators. The MK XII system was developed with two primary goals. The first goal was to provide improved air traffic control (ATC) for both civil and military aircraft, as well as a method for monitoring the identification codes of friendly military aircraft and surface vessels. The second goal was to furnish a crypto-secure method of identifying military craft.

Air traffic control, including the monitoring of friendly aircraft code, track, and altitude information, requires the use of the selective identification feature (SIF) modes 1, 2, 3/A, and mode C. Remember, numbered modes form part of the military IFF MK XII system; lettered modes are assigned to the civil air traffic control system. Ships can also be monitored with the SIF modes. A feature known as *interrogator side lobe suppression (ISLS)* inhibits transponder replies to all challenges not radiated in the main beam of the interrogating antenna. Without the ISLS feature, a close-range IFF target would appear at several different bearings on the display (a phenomenon known as *ring-around*). If ring-around appears on more than one target, it probably indicates a problem with the ship's interrogation system. All MK XII interrogators and transponders incorporate the ISLS function.

NOTE

Transponder systems without ISLS capability may be operated in the low-sensitivity position to reduce undesired replies from the antenna pattern side lobes.

Each mode 1, 2, or 3/A transponder reply represents a binary coded octal number. The desired octal reply code for each mode is dialed into the transponder by means of thumb-wheel switches. Reply codes available are as follows:

Mode 1	32 two-digit codes (00 to 73) , selected at the C6280A(P)/APK.
Mode 2	4096 four-digit codes (0000 to 7777), selected at the RT-859A/APX-72 front panel.
Mode 3/A	4096 four-digit codes (0000 ton 7777), selected at the C-6280A(P)/APX front panel.
Mode C	1278 four-digit codes. These codes represent altitudes from–1,000 feet to + 126,700 feet in 100-foot increments and are generated by an aircraft's barometric altimeter digitizer. Shipboard transponders reply to mode C interrogations with bracket pulses only (code 0000).
Mode 4	Computer-controlled crypto code, generated automatically according to a preset key list (AKAK 3662 series).

You cannot distinguish mode 1, 2, 3/A, and C by mode. Only the fact that the interrogator system "remembers" which mode it has just interrogated allows replies to be identified with the proper mode.

Mode 4 provides crypto-secure identification of friendlies. Mode 4 interrogations are computer-encoded pulse trains, which consist of four "sync" pulses and possibly an ISLS pulse (if it is not transmitted in the antenna's main lobe) followed by as many as 32 information pulses. Upon receipt of a valid mode 4 interrogation, the transponder computer processes the information "word" and generates a corresponding time-encoded three-pulse reply. The interrogator subsystem, in turn, receives the reply, converts it to one pulse, and time-decodes it for presentation on the indicators.

Q1. What two subsystems make up an IFF system?

Q2. What IFF mode provides the altitude of a contact? What range of altitudes does this mode indicate?

MK XII IFF EQUIPMENT OPERATION

Figure 8-1 shows a MK XII shipboard system. The dashed lines separate equipment that is connected electronically but located in different parts of the ship.

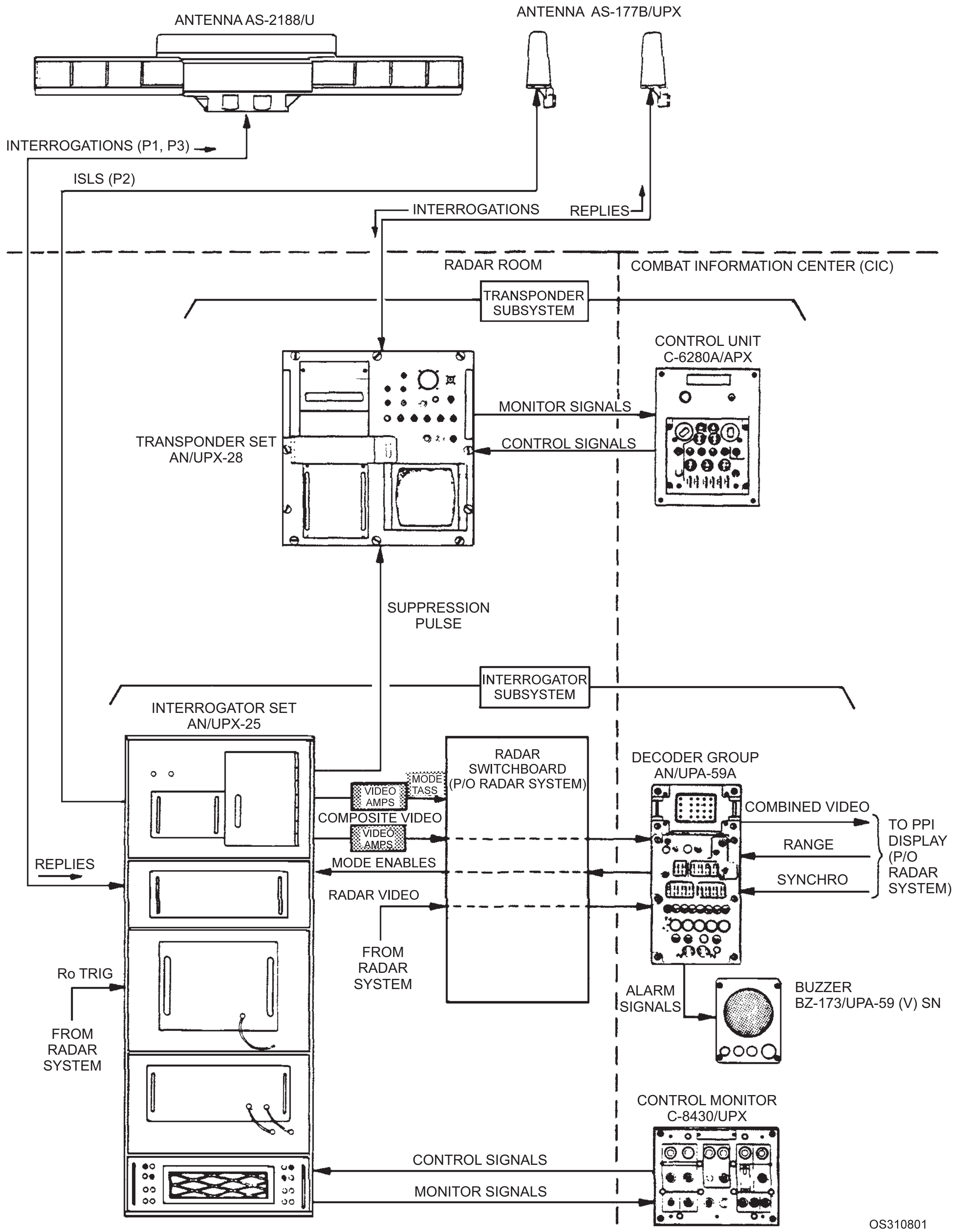


Figure 8-1.—Typical AIMS shipboard system.

The equipment shown to the right of the vertical dashed line, under COMBAT INFORMATION CENTER, is the equipment with which you will be most concerned. This equipment operates associated equipment located in the radar room. Notice that figure 8-1 also divides the equipment by subsystem—transponder and interrogator. We will discuss each system briefly.

TRANSPONDER SUBSYSTEM

Your ship will be equipped with one of two transponder subsystems—either the AN/APX-72 or the AN/APX-100. The AN/APX-100 was designed as a direct replacement for the AN/APX-72. The AN/APX-72, which is found in most shipboard naval configurations, consists of Receiver-Transmitter RT-859A/APX-72 and Transponder Set Control C-6280P/APX. The control unit is normally operated from a remote location in the combat information center. In comparison, the AN/APX-100 consists of Receiver-Transmitter RT-1157A/APX-100 and Transponder Set Control C-10533/APX-100, which again is normally operated from a remote location.

The two systems are functionally almost identical. However, the AN/APX-100 has several enhancements that are lacking in the AN/APX-72. The newer transponder is smaller, lighter and uses solid state transmitters and receivers, which greatly increases the reliability of the unit.

For airborne platforms, the AN/APX-100 has a diversity function that uses two separate antennas (ships use only one) and receiver circuits. This feature reduces the number of missed replies that are caused by the aircraft's angle in relation to the location of the interrogating platform. Another improvement introduced in the AN/APX-100 is the built-in test function. The self-tests performed by Transponder Test Set TS-1843/ APX, which was a separate unit in the older transponder, are performed by the RT-1157A/APX-100 without the need of additional test equipment. Also, the mode 4 self-test capability in the AN/APX-100 is a significant improvement over the AN/APX-72.

Transponder Set Control C-6280A(P)/APX

The Transponder Set Control C-6280A(P)/APX contains switches and indicators that allow an operator to turn on the transponder subsystem, to set in the reply codes for modes 1 and 3/A; to test modes 1, 2, 3/A, and C; to select the mode 4A or 4B code word; and to control the operation of the mode 4 computer or zero the mode 4 code. Figure 8-2 identifies each of the switches and indicators. Although you may be called on to operate this piece of equipment, your supervisor will normally operate it.

Transponder Set Control C-10533/APX-100

As we stated above, Transponder Set Control C-10533/APX-100 was designed to replace Transponder Set Control C-6280A(P)/APX Operationally, the two control units function similarly. The main difference is in the layout of the front panel controls and indicators. Figure 8-3 shows the layout of Transponder Set Control C-10533/APX-100. The most significant addition to the C-10533/APX-100 is the incorporation of the status indicators on the front panel.

INTERROGATOR SUBSYSTEM

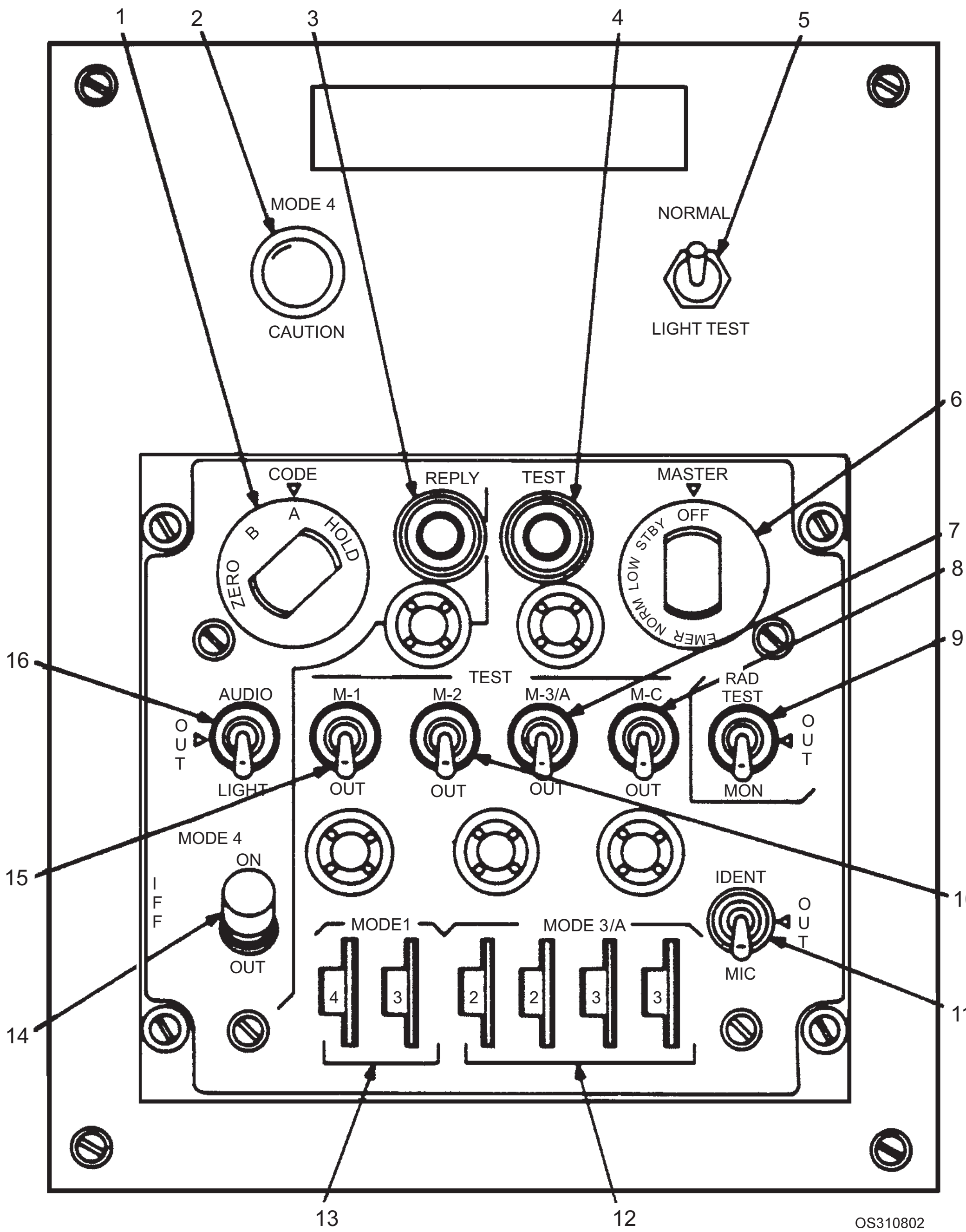
The two pieces of equipment of concern to you in the interrogator group are the *decoder group* and the *control monitor*. Our discussion on the decoder group is somewhat lengthy, so we will cover the control monitor first.

Control Monitor C-8430/UPX

The Control-Monitor C-8430/ provides remote control and remote indication for certain key functions of the interrogator subsystem. Figure 8-4 shows the controls and indicators you will find on the C-8430/UPX Control-Monitor. The two functions of primary concern to you are the *defruite*r function and the *mode 4* function.

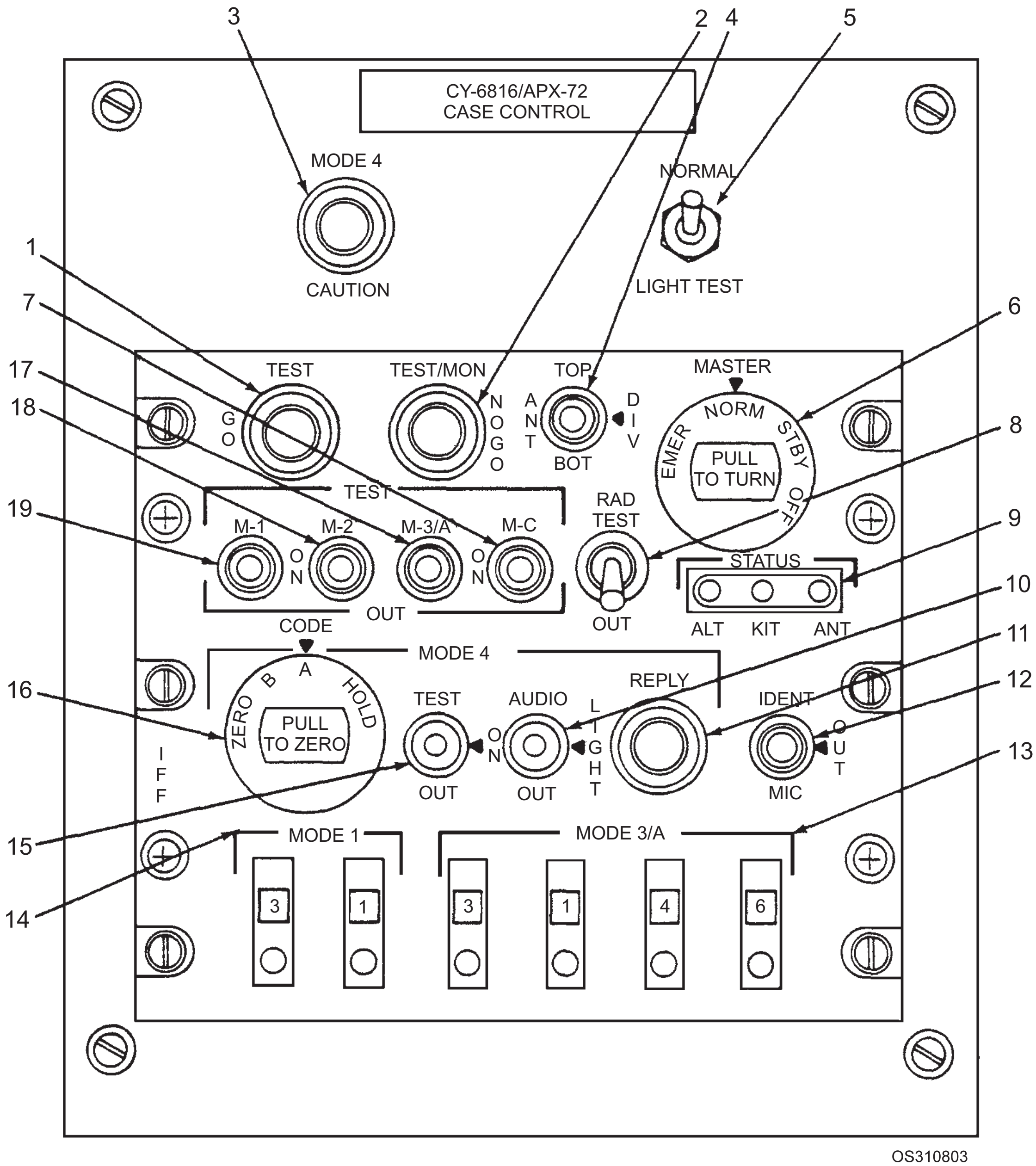
The defruiter controls provide remote control for the Interference Blanker MX-8758/UPX (defruiter). The defruiter removes non-synchronous transponder replies (that is, replies responding to other interrogations-known as "fruit") and noise from received video.

Recall that mode 4 is used for crypto purposes. The mode 4 controls provide remote control for certain functions of the KIR-1A/TSEC computer.The control settings on this component affect the total interrogator system operation, including all decoders and NTDS equipment selecting this system. The control-monitor should be operated only by qualified personnel, knowledgeable in overall system operation. There will be one Control-Monitor C-8430/UPX for each interrogator subsystem aboard ship.



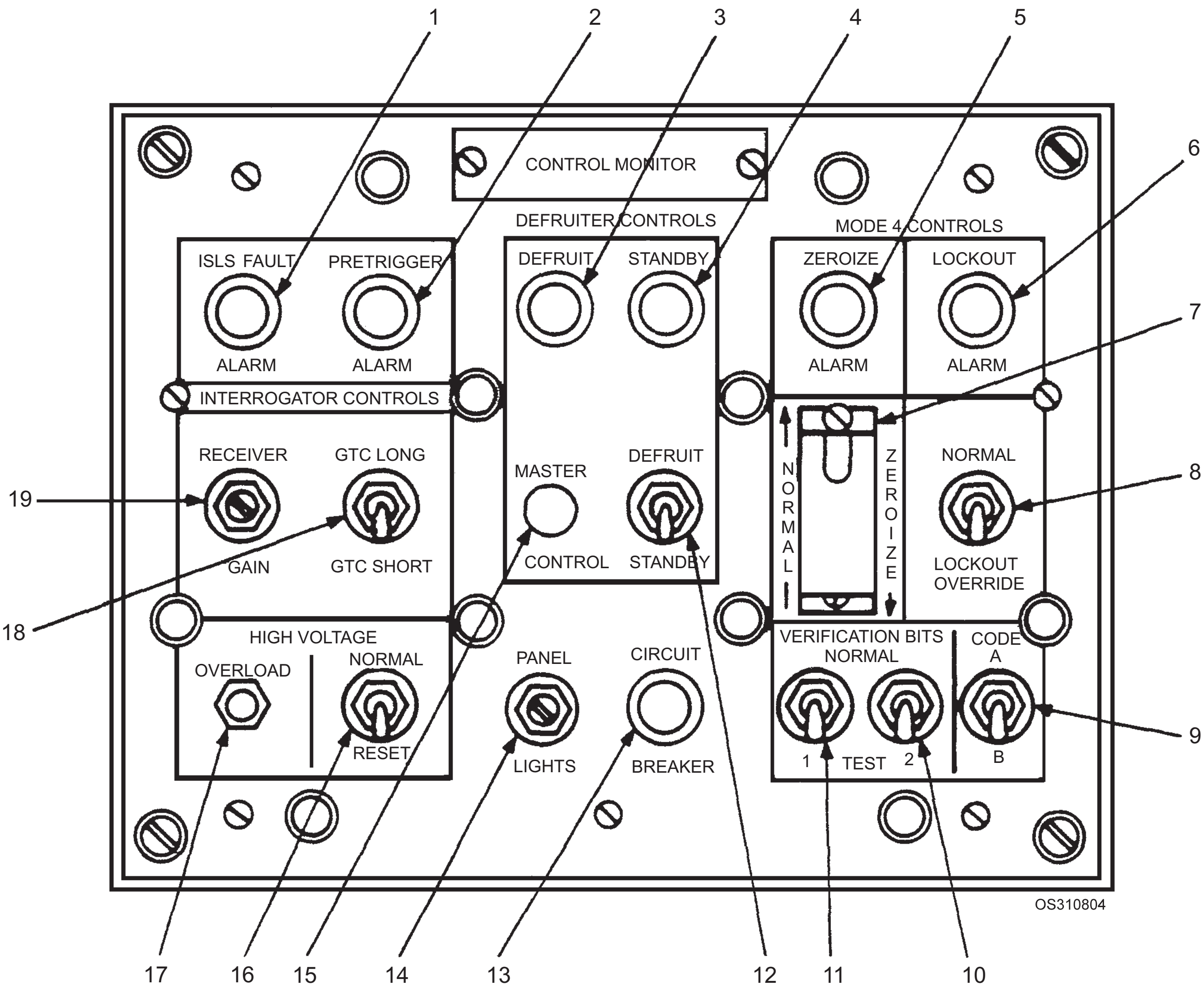
1. Code switch
2. Mode 4 Caution indicator
3. Replay indicator
4. Test indicator
5. Normal/Light Test indicator
6. Master switch
7. M-3/A switch
8. M-C switch
9. Rad Test/Out/Mon switch
10. M-2 switch
11. Ident/Out/Mic switch
12. Mode 3/A code select switches
13. Mode 1 code select switches
14. Mode 4 switch
15. M-1 switch
16. Audio/Out/Light switch

Figure 8-2.—Transponder Set Control C-6280A(P)/APX in Control Enclosure CY-6816/APX-72.



1. Test Go indicator
2. Test/Mon No Go indicator
3. Mode 4 Caution indicator
4. Ant Top/Div/Bot switch
5. Light Test switch
6. Master control
7. M-C switch
8. Rad Test/Out switch
9. Status indicator
10. Audio/Out/Light switch
11. Reply indicator
12. Indent/Out/Mic switch
13. Mode 3/A switches
14. Mode 1 switches
15. Mode 4 switch
16. Code switch
17. M-3/A switch
18. M-2 switch
19. M-1 switch

Figure 8-3.—Transponder Set Control C-10533/APX-100 mounted in Enclosure CY-6816/APX-72.



1. ISLS Fault Alarm indicator
2. Pretrigger Alarm indicator
3. Defruit indicator
4. Standby indicator
5. Mode 4 Zeroize Alarm indicator
6. Mode 4 Lockout Alarm indicator
7. Mode 4 Normal/Zeroize switch
8. Mode 4 Normal/Lockout Override stitch
9. Mode 4 Code switch
10. Verification Bit 2
11. Verification Bit 1
12. Defruit/Standby switch
13. Circuit breaker
14. Panel Lights dimmer control
15. Defruiter Master Control indicator
16. Interrogator High Voltage Normal/Reset switch
17. Interrogator High Voltage Overload indicator
18. Interrogator GTC Long/GTC Short switch
19. Interrogator Receiver Gain control

Figure 8-4.—Control-Monitor C-8430/UPX.

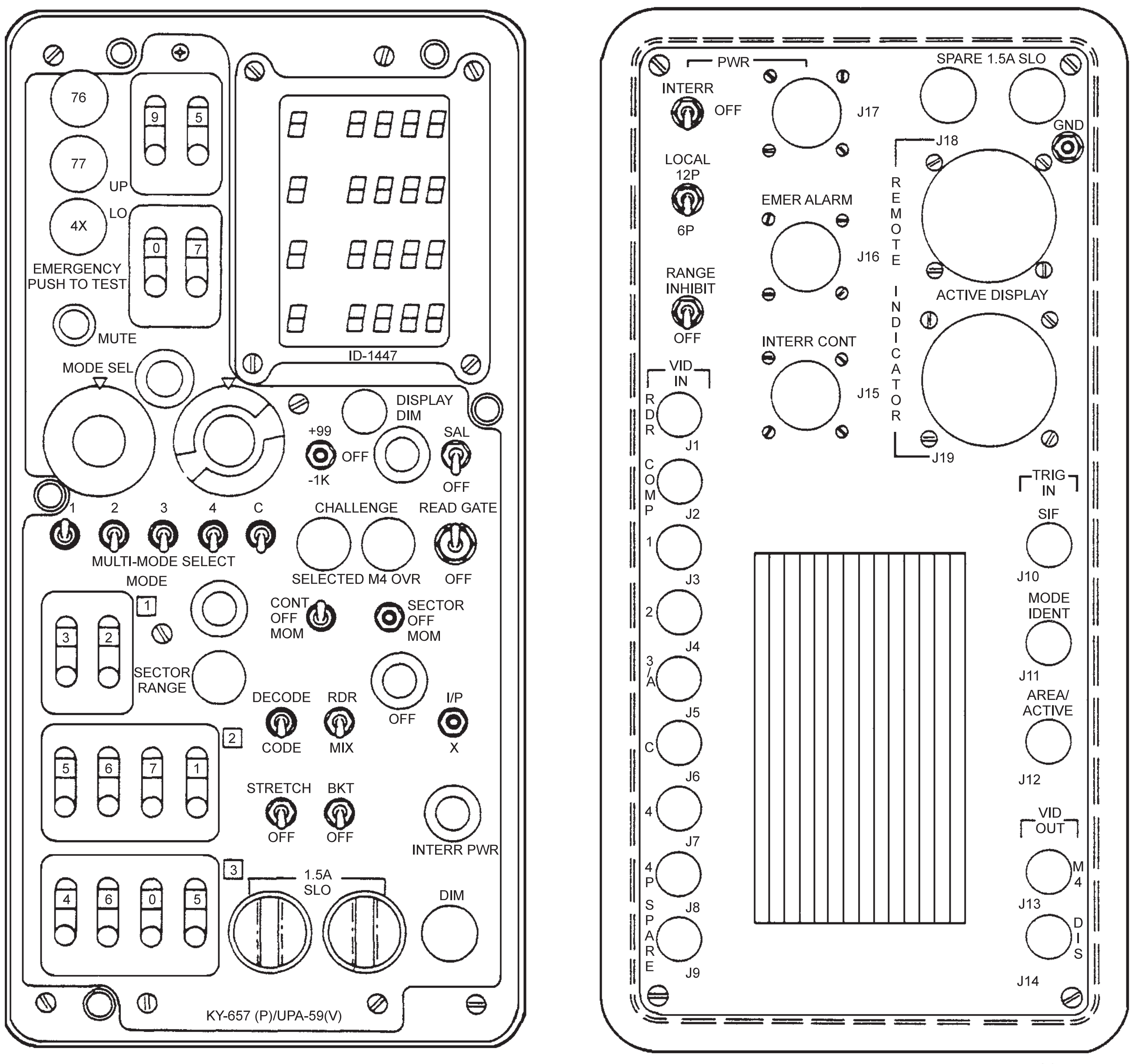
Decoder Groups AN/UPA-59, 59A, and 59B(V)

The AN/UPA-59 Decoder Group is a combination decoder/interrogator set remote control unit. It allows you to select the mode (and code) you desire to interrogate and to process the IFF video replies for presentation. It also provides remote challenge and emergency alarm indications.

Three different models of decoder groups are used with the interrogator subsystem: AN/UPA-59(V), AN/UPA-59A(V), or AN/UPA-59B(V).

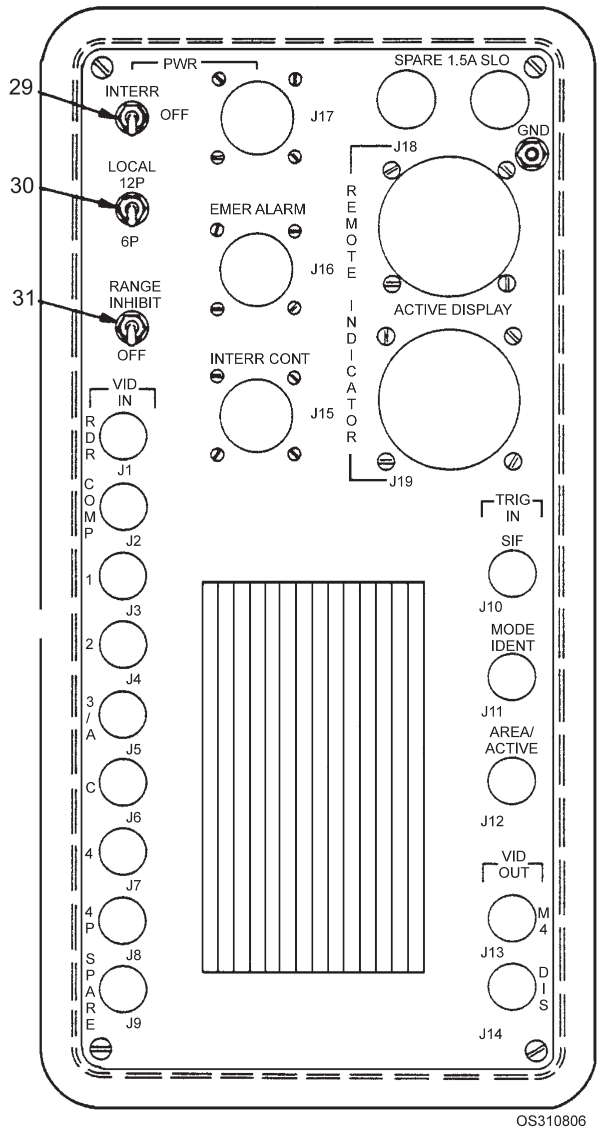
DECODER GROUP AN/UPA-59(V).—Decoder Group AN/UPA-59(V) (Figures 8-5 and 8-6) consists of three major components: Video Decoder KY-657(P)/UPA-59(V), Intratarget Data Indicator ID-1447/UPA-59(V), and Alarm Monitor BZ-173/UPA-59A(V).

The Video Decoder KY-657(P)/UPA-59(V) allows you to control the interrogation mode and the passive decoding of IFF replies. It also enables you to select the video to be sent to the radar repeater/display unit.



A. FRONT VIEW OF VIDEO DECODER B. REAR VIEW OF VIDEO DECODER

Figure 8-5.—Decoder Group AN/UPA-59(V2) front and rear panels.



29. Pwr Local/Off/Interr switch
30. 12P/6P switch
31. Range Inhibit/Off switch

Figure 8-6.—Decoder AN/UPA-59 controls (rear panel).

The Intratarget Data Indicator ID-1447/ UPA-59(V) displays a code readout for modes 1, 2, 3/A, and C.

The Alarm Monitor BZ-173/UPA-59A(V) notifies you that an aircraft is "squawking" (transmitting) an emergency code and needs your attention.

DECODER GROUP AN/UPA-59A(V).— Decoder Group AN/UPA-59A(V) (Figure 8-7) consists of Video Decoder KY-761(P)/UPA-59A(V), Intratarget Data Indicator ID-1844/UPA-59A(V), and Alarm Monitor BZ- 173A/UPA-59(V).

Video Decoder KY-761(P)/UPA-59A(V) functions substantially the same as the KY-657(P)/UPA-59(V).

Intratarget Data Indicator ID-1844/UPA-59A(V) functions the same as the ID- 1447/UPA-59(V).

Alarm Monitor BZ- 173A/UPA-59(V) functions the same as the BZ-173/UPA-59(V).

DECODER GROUP AN/UPA-59B(V).— Decoder Group AN/UPA-59B(V) (Figure 8-8) consists of Video Decoder KY-761A(P)/ UPA-59A(V)[P/O AN/UPA-59B(V)], Intratarget Decoder Indicator ID-1844A/UPA-59A(V)[P/O AN/UPA-59B(V)], and Alarm Monitor BZ-173A/ UPA-59(V).

Video Decoder KY-761A(P)/UPA-59A(V)[P/O AN/UPA-59B(V)] functions substantially the same as the KY-657(P)/UPA-59(V).

Intratarget Decoder Indicator ID-1844A/UPA-59A(V)[P/O AN/UPA-59B(V)] functions the same as the ID-1447/UPA-59(V).

Alarm Monitor BZ-173A/UPA-59(V) functions the same as the BZ-173/UPA-59(V).

Note: Decoder Group AN/UPA-59B(V) appears the same as Decoder Group AN/UPA-59A(V) except for the BKT/OFF switch which becomes a three position switch labeled BKT/OFF/ALL.

Two configurations of the decoder groups are used in today's Navy: Variation 1, (V)1, consists of a video decoder and the alarm monitor. This configuration is referred to as a *passive* decoder. Passive functions are those that "filter" information to the indicator for display. Variation 2, (V)2, adds the intratarget data indicator to variation 1. This configuration is known also as an *active* decoder. Active functions are those in which the codes of targets in the active area on the display are read out on the intratarget data indicator.

The active and passive decoders perform passive decoder functions in the same manner. The (V)2 configuration adds active decoding capabilities to the passive functions of the (V)1 configuration. Passive and active functions are separate. In fact, under certain operational conditions, active readouts can occur for targets whose IFF video is not displayed on the associated indicator. We will address the active and passive functioning separately, with the discussion on passive decoding applying to the (V)1 configuration, and the discussion on **both** passive and active decoding applying to the (V)2 configuration.

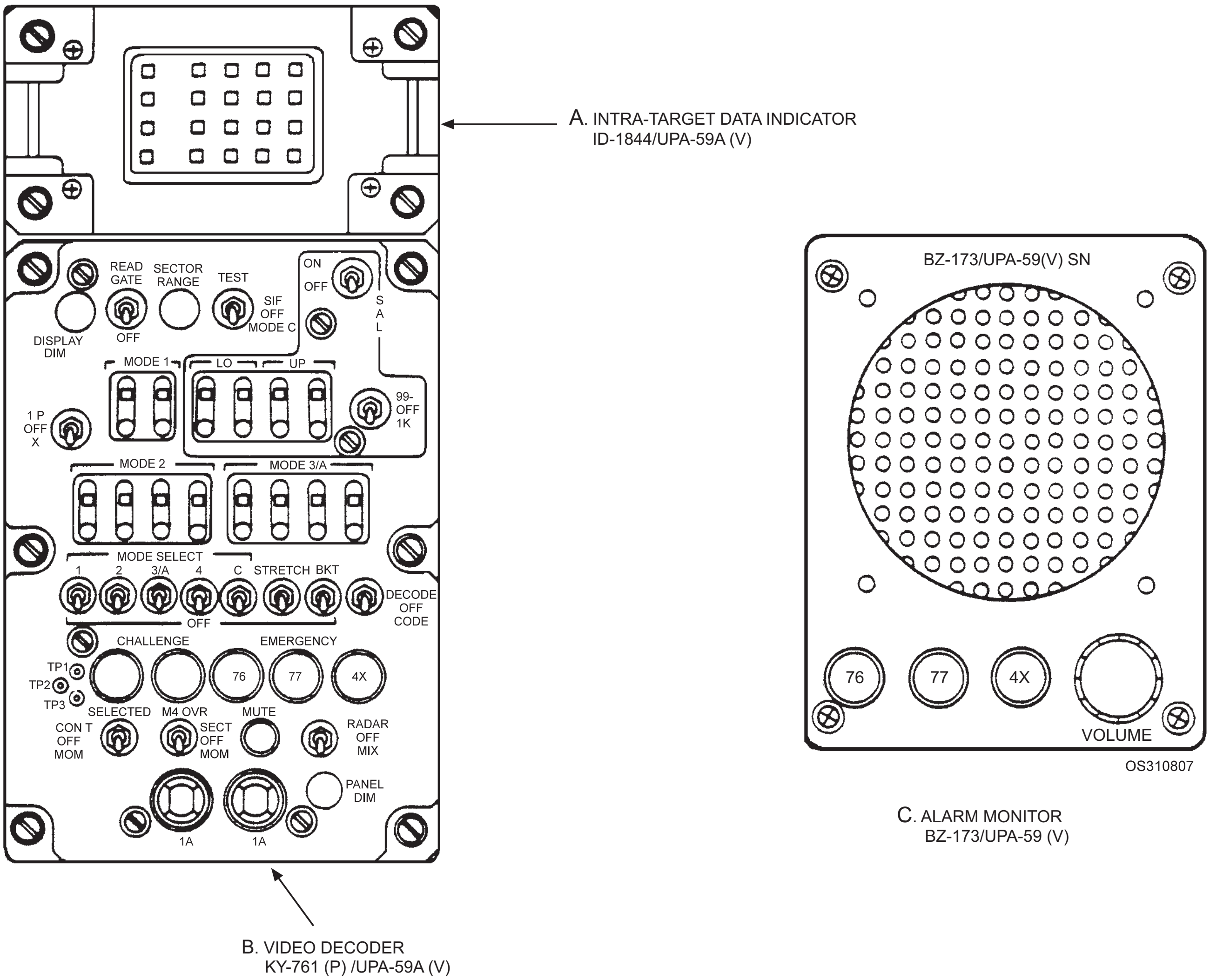


Figure 8-7.—Decoder Group AN/UPA-59A(V2).

NOTE

If more than one decoder is used in an operational area (e.g., surface search), only one video decoder needs to be configured with an alarm monitor.

DECODER SWITCH SETTINGS AND DISPLAYS.—Switch positions for the AN/UPA-59's various modes of operation are listed in table 8-1; switch positions for the AN/UPA-59A and AN/UPA-59B are listed in tables 8-1 and 8-2. You can energize an active or passive decoder by using the three switches located on the decoder's rear panel. See figure 8-6 for the rear panel of AN/UPA-59, and figure 8-9 for the rear panel of AN/UPA-59A and 59B, which are basically the same.

Power LOCAL/OFF/INTRG Switch (29).—This switch energizes the video decoder. When the switch is in the INTRG position, the associated interrogator must be ON. When it is in the LOCAL position, the associated interrogator need not be on. Power must be applied to the associated display unit for both switch positions to function. The normal position of the switch is INTRO; the LOCAL position is reserved for emergency operation only. The interrogator associated with a video decoder group is selected automatically when a radar is selected at the PPI.

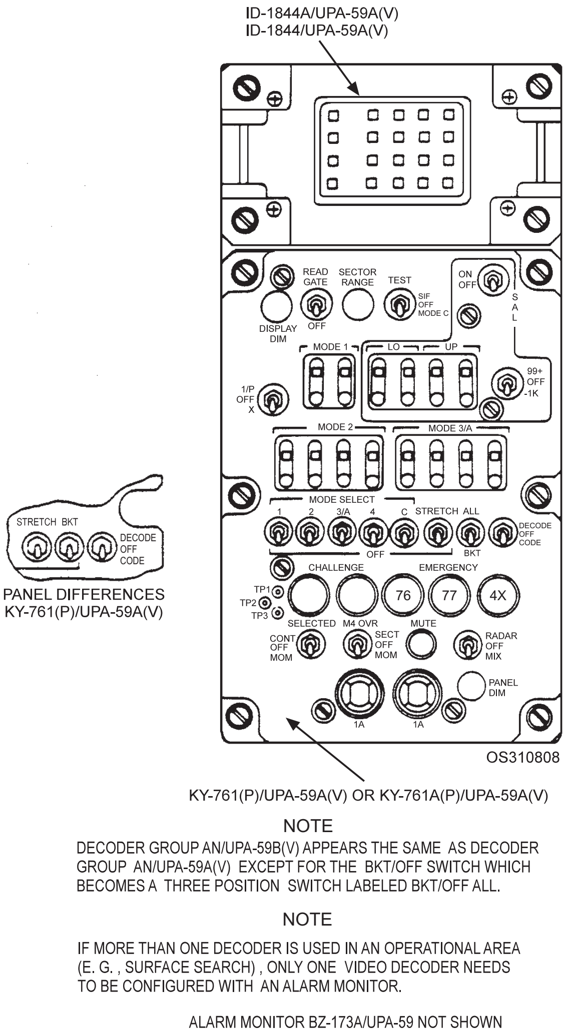
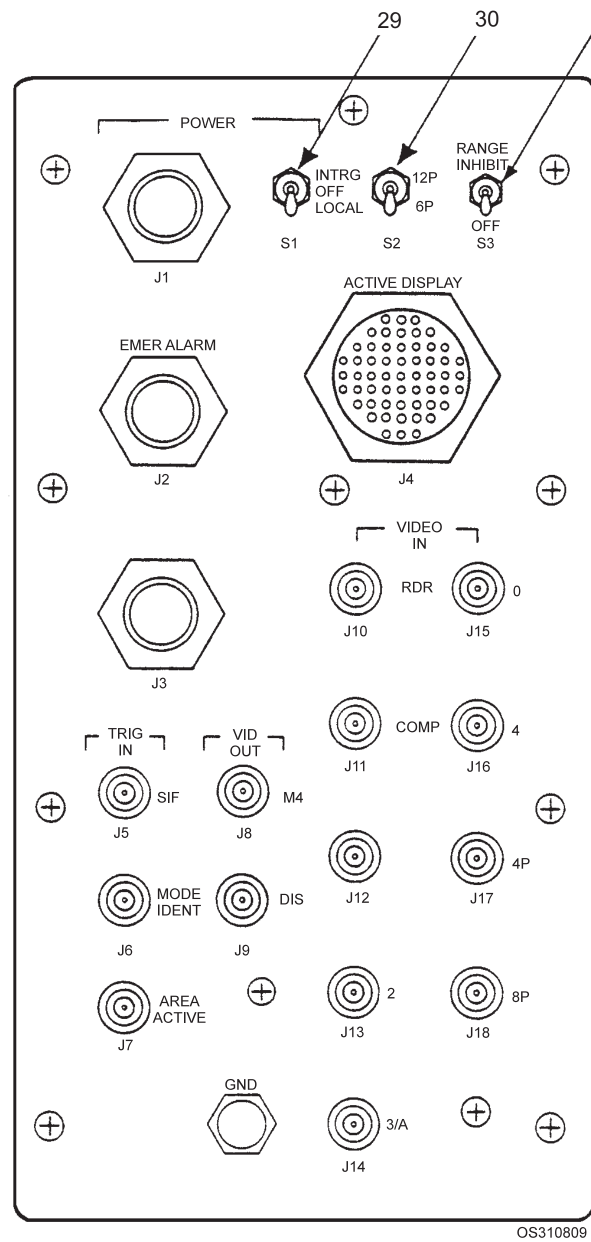


Figure 8-8.—Decoder Group AN/UPA-59B(V2).



29. Power Local/OFF/Intrg switch
30. 12P/6P switch
31. Range Inhibit/Off switch

Figure 8-9.—Decoder AN/UPA-59A and 59B controls (rear panel).

NOTE

> The POWER DISABLE switch, located internally (fig. 8-10), must be in the ON position; otherwise, the POWER- LOCAL/ OFF INTRO switch will not energize the decoder.

12P/6P Switch (30)—When the 12P/6P switch is in the 6P position, the decoder will decode six-pulse replies (i.e., the A and B digits only) for modes 2 and 3. When it is in the 12P position, the decoder will decode twelve-pulse replies (i.e., the A, B, C, and D digits) for modes 2 and 3. The normal position is 12P.

RANGE INHIBIT/OFF Switch (31).—The RANGE INHIBIT position of this switch prevents the decoding of false emergency replies from a close-range target. The inhibit range is internally adjustable and normally is set for 5 miles. The switch does not affect emergency replies from targets beyond the set range. The normal switch position is OFF. When your ship is operating within 5 miles of units doing preflight testing, use the RANGE INHIBIT position to prevent decoding false emergency replies.

Table 8-1.—Decoder Control Positions for Desired Functions

	CONTROL POSITIONS																
Desired Function	*Mode Select	**Test/ Parity	***Multi-Mode Select	Selected	Code/ Decode	RDR/ Mix	Bkt	Stretch	IP/X	Code Switches	Sal	Up	Lo	+99/-1K	M4 Over	Read Gate	6P/12P
Code Display	Note 2	Off	Note 3	Cont	Code	Off or Mix	Off	Note 1	Note 1	Note 1	Off	Note 1	Note 1	Note 1	Off	Note 4	Note 1
Passive Decode	Note 10	Off	Note 3	Cont	Decode	Off or Mix	Off	Note 8	Note 7	Set selected mode to desired code	Off	Note 1	Note 1	Note 1	Off	Note 4	Note 6
Bracket Decode	Note 5	Off	Note 3	Cont	Decode	Off or Mix	Bkt	Off	I/P or Off	Note 1	Off	Note 1	Note 1	Note 1	Off	Note 4	Note 1
Stretched Passive Decode plus Bracket Decode	Note 5	Off	Note 3	Cont	Decode	Off or Mix	Bkt	Stretch	Note 7	Set selected mode to desired code	Off	Note 1	Note 1	Note 1	Off	Note 4	Note 6
I/P Decode	Note 10	Off	Note 3	Cont	Note 8	Off or Mix	Note 8	Note 8	I/P	Note 9	Off	Note 1	Note 1	Note 1	Off	Note 4	Note 6
X-Pulse Decode Display	Note 10	Off	Note 10	Cont	Decode	Off or Mix	Off	Off	X	Set selected mode to desired code	Off	Note 1	Note 1	Note 1	Off	Note 4	Note 6
Stretched X-Pulse Decode Plus Bracket Decode	Note 10	Off	Note 10	Cont	Decode	Off or Mix	Bkt	Stretch	X	Set selected mode to desired code	Off	Note 1	Note 1	Note 1	Off	Note 4	Note 6
4X Emergency	Note 11	Off or any Parity Mode	Note 11	Cont	Note 1	Off or Mix	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Off	Note 1	Note 1
7600 Emergency	Note 12	Off or any Parity Mode	Note 12	Cont	Note 1	Off or Mix	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Off	Note 1	Note 1

OS3108t1

Table 8-1.—Decoder Control Positions for Desired Functions (Continued)

	CONTROL POSITIONS																
Desired Function	*Mode Select	**Test/ Parity	***Multi-Mode Select	Selected	Code/ Decode	RDR/ Mix	Bkt	Stretch	IP/X	Code Switches	Sal	Up	Lo	+99/-1K	M4 Over	Read Gate	6P/12P
7700 Emergency	Note 12	Off or any Parity Mode	Note 12	Cont	Note 1	Off or Mix	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Off	Note 1	Note 1
Combined Emergency	Note 12	Off or any Parity Mode	Note 12	Cont	Note 1	Off or Mix	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1	Off	Note 1	Note 1
Sal Decode UPA-59A/B	Mode C			Cont	Decode or Off	Off or Mix	Off	Off	Note 1	Note 1	Sal	Note 13	Note 13	Note 14	Off	Note 4	Note 1
Sal Parity Code Display UPA-59 only	Select Mode C plus desired parity mode	Set for desired Parity Mode	Note 3	Cont	Code	Off or Mix	Off	Off	Note 1	Note 1	Sal	Note 13	Note 13	Note 14	Off	Note 4	Note 1
Sal Parity Decode Display UPA-59 only	Select Mode C plus desired parity mode	Set for desired Parity Mode	Note 3	Cont	Decode	Off or Mix	Off	Stretch	Note 8	Set Parity mode to desired code	Sal	Note 13	Note 13	Note 14	Off	Note 4	Note 6
Sal Bracket Decode Disply UPA-59 only	C or Multi-Mode	Off	Note 15	Cont	Note 1	Off or Mix	Bkt	Off	Off	Note 1	Sal	Note 13	Note 13	Note 14	Off	Note 4	Note 1
Sal Bracket Decode plus Sal Parity Decode UPA-59 only	Select Mode C plus desired parity mode	Set for desired Parity Mode	Note 3	Cont	Decode	Off or Mix	Bkt	Stretch	Note 8	Set Parity mode to desired code	Sal	Note 13	Note 13	Note 14	Off	Note 4	Note 6
Mode 4 Sector Override	Note 8	Off or Parity	Note 3	Note 8	Note 8	Off or Mix	Note 8	Note 8	Note 8	Note 8	Note 8	Note 8	Note 8	Note 8	Sector	Note 4	Note 8
Mode 4 Momentary Override	Note 8	Off or Parity	Note 3	Note 8	Off or Mix	Note 8	Note 8	Note 8	Note 8	Note 8	Note 8	Note 8	Note 8	Note 8	MOM as desired	Note 4	Note 8

NOTES:

OS3108t2

1. Switch position is immaterial.
2. Any mode or combination of modes is selectable as desired by operator.
3. Switch positions are immaterial unless MULTIMODE is selected on the MODE SEL switch in which case the multimode switches determine which modes are enabled.
4. The READ GATE switch is used to enable active readout, plus active area gate for display.
5. Any mode or combination of modes selectable. Mode 4, if selected, will be passed to the PPI directly.
6. Selection of 12P causes all four digits of a mode 2 or mode 3 reply code to be decoded. Selection of 6P causes decoder to ignore the last wo (C and D) digits for decoding.
7. Selection of I/P causes stretched slash to follow reply of targets transmitting an I/P code. Selection of the X position requires presence of X-pulses (signifying pilotless aircraft) in the reply code, in addition to the requirement that the reply code match the associated mode code switch setting, for passive decode to occur.
8. Selectable as desired by operator.
9. Set the desired code for selected mode if in passive decode format.
10. Modes 1. 2. 3/A or any combination thereof may be selected. Mode 4 video, if selected, will be passed to the PPI, unprocessed by the decoder.
11. Any mode or combination of modes containing at least one of modes 1, 2, 3/A may be selected.
12. Mode 3/A or any combination of modes including mode 3/A may be selected.
13. Set for desired altitude layer.
14. Plus 99 eliminates upper SAL limit, -1k eliminates lower SAL limit.
15. Mode C or any combination of modes including mode C.

* Mode SEL switch on UPA-59 only
** Parity selection on UPA-59 only
*** MULTI-MODE SELECT switches labeled MODE SELECT on UPA-59A/B decoders

Table 8-2.—Operator's Control Functions

	SAL	STRETCH	BKT	DECODE OFF CODE	DISPLAYED VIDEO
1	ON	ON	ALL or BKT	DECODE	All mode C within UP and LO SAL limits and all passively decoded replies stretched. Remaining targets show a single slash due to bracket decoding.
2.	OFF	ON	ALL or BKT	DECODE	Same as 1. above, but without mode C.
3.	ON	OFF	ALL or BKT	DECODE	All targets display single slash with no differentiation for SAL, bracket decoded, or passively.
4.	OFF	OFF	ALL or BKT	DECODE	Same as 3. above, but without mode C.
5.	ON	ON	OFF	DECODE	All passively decoded replies and all SAL stretched.
6.	OFF	ON	OFF	DECODE	All passively decoded replies stretched.
7.	ON	OFF	OFF	DECODE	All passively decoded replies and all SAL display single slash.
8.	OFF	OFF	OFF	DECODE	All passively decoded replies display single slash.
9.	(1)	(1)	ALL or BKT	OFF	All targets display single slash (includes mode C targets, if SAL turned on).
10.	ON	ON	OFF	OFF	All SAL targets within UP & LO SAL limits stretched.
11.	OFF	(1)	OFF	OFF	Emergency replies only.
12.	ON	OFF	OFF	OFF	All SAL targets within UP & LO SAL limits.
13.	(1)	(1)	(1)	CODE	IFF info pulses (raw video).

NOTE: (1) Switch position is immaterial.

NOTE

The remaining controls are located on the front panel. See figure 8-11 for the AN/UPA-59, and figure 8-12 for the AN/UPA-59A or AN/UPA-59B.

Panel Lighting DIM Control (14).—The DIM control adjusts panel light brightness.

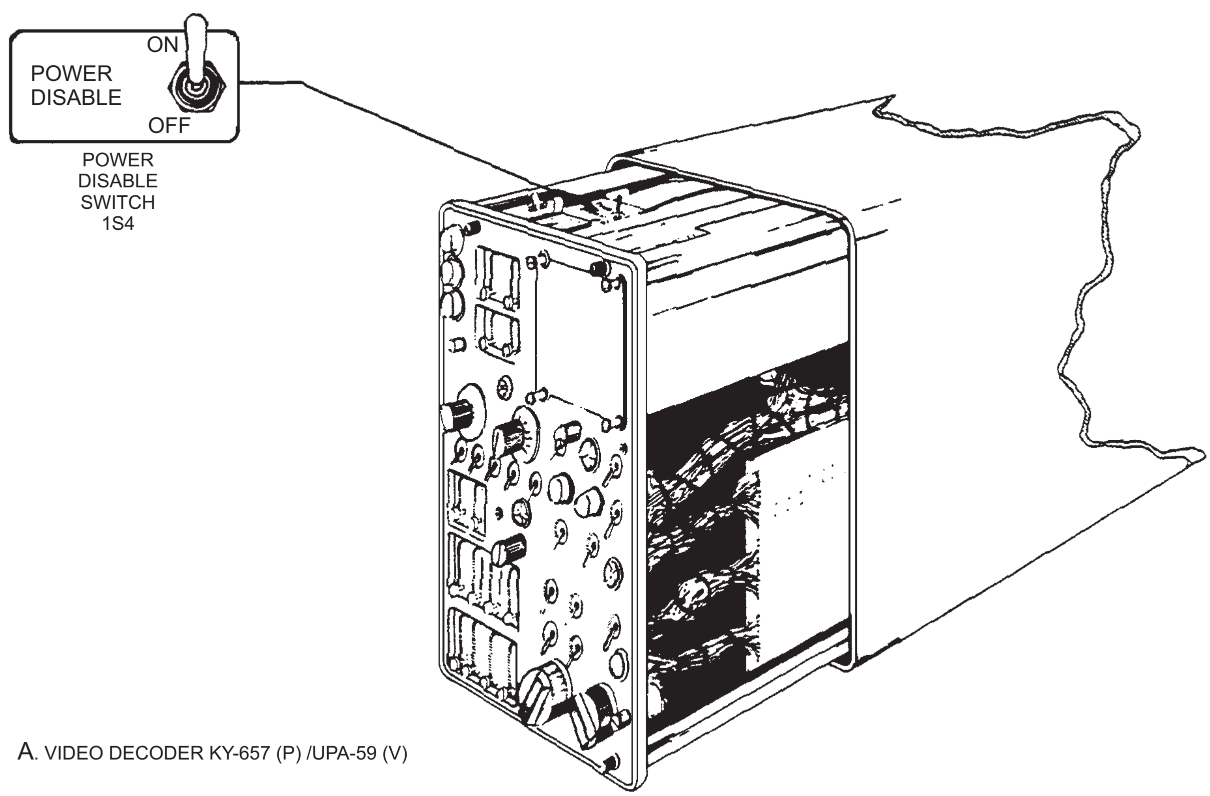
READ GATE Switch (functions with (V) 2 only) (2).—In the READ GATE position, this switch activates the active readout display.

SECTOR RANGE control (functions with (V)2 only) (3).—This control adjusts the range (length) of the target sector gate (active area gate). See figure 8-13.

Active Readout Lighting (intratarget data indicator) DISPLAY DIM Control (functions with (V)2 only) (28).—This control adjusts the readout for desired brightness.

CAUTION

When a decoder SELECTED CONT/OFF/MOM switch is left in the CONT position, the interrogator set may transmit challenges even when the decoders are powered OFF (if any modes are selected).



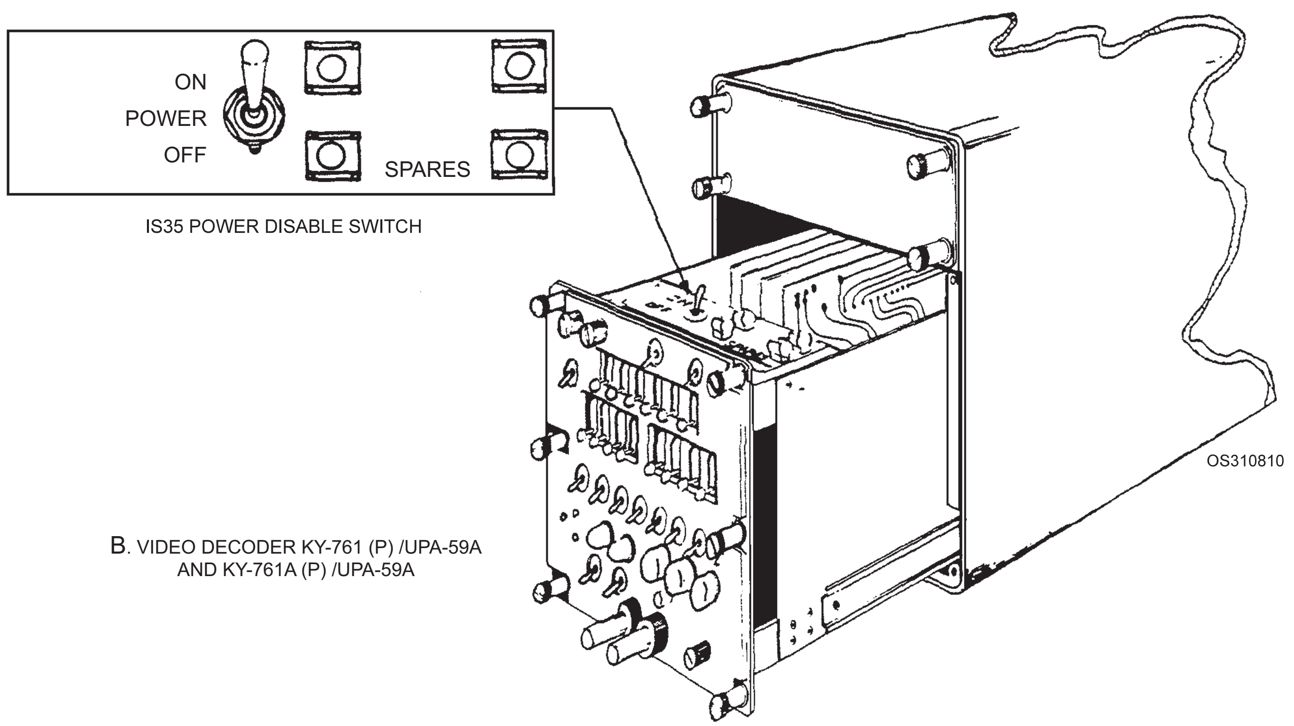
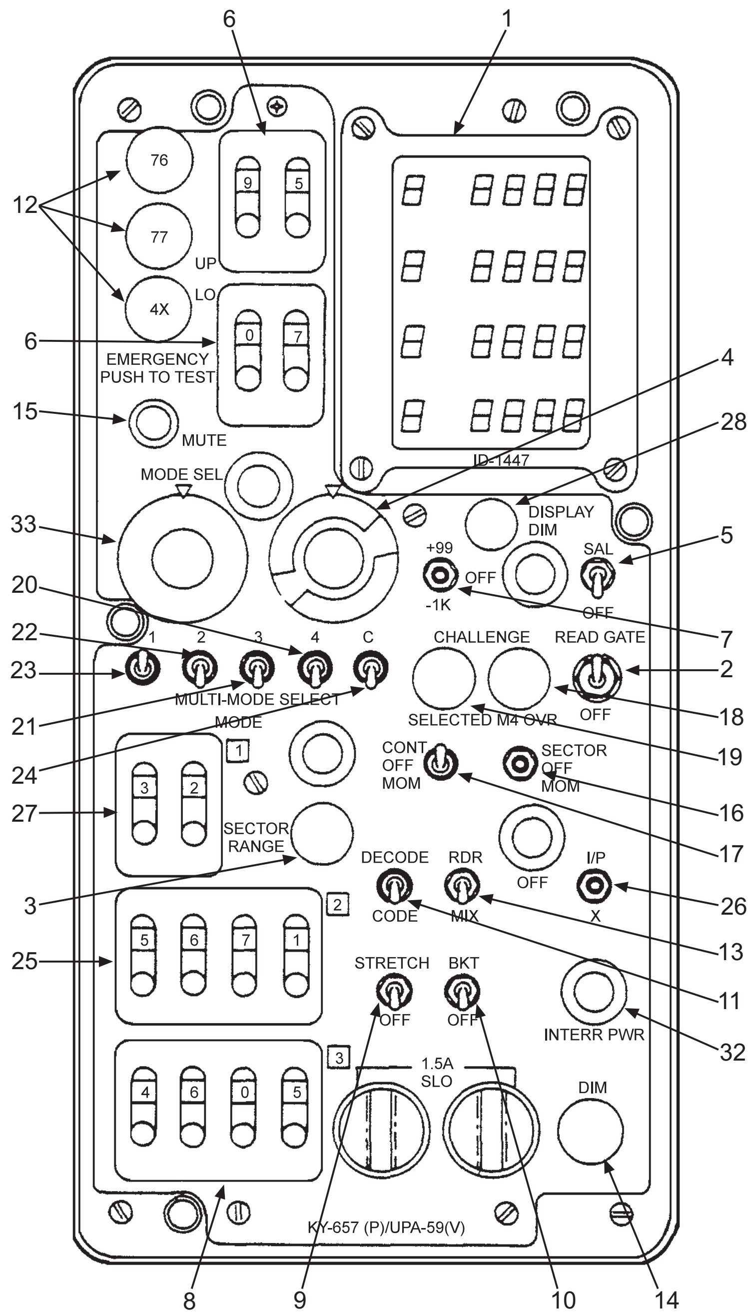
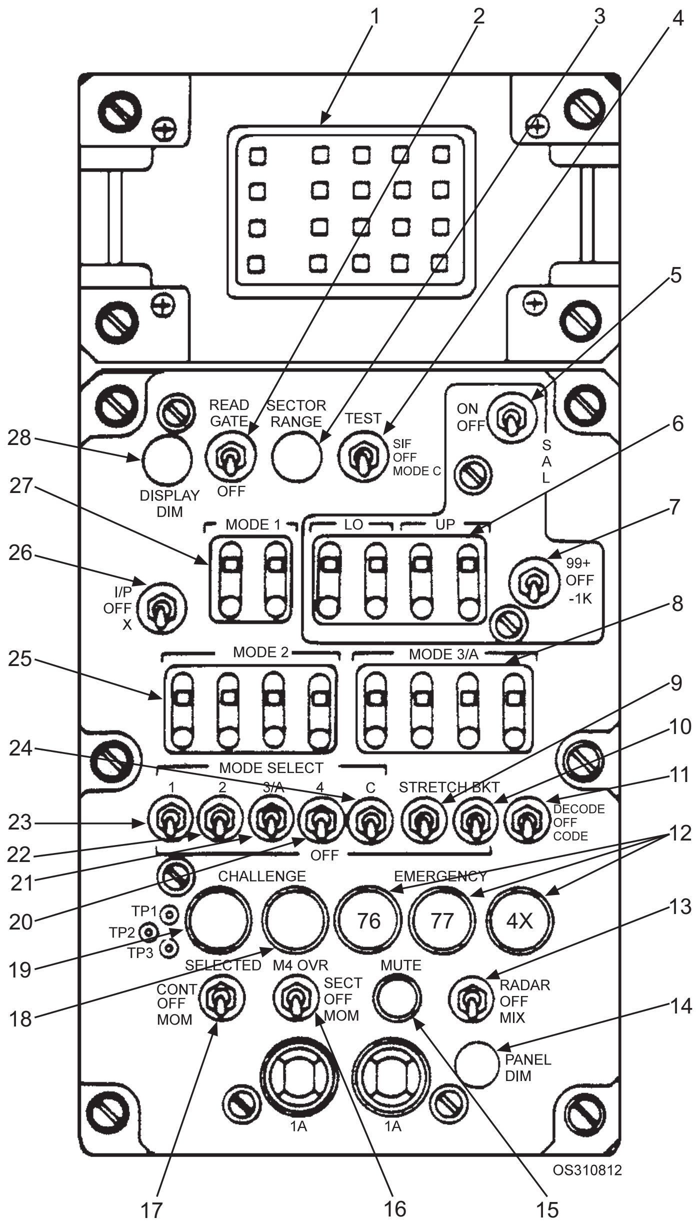


Figure 8-10.—Video decoder power disable switch locations.



1. Intertarget data indicator
2. READ GATE/OFF switch
3. SECTOR RANGE control
4. PARTY/OFF/TEST switch
5. SAL ON/OFF switch
6. LO switch
7. SAL 99+ /OFF/-1K switch
8. MODE 3 code switch
9. STRETCH/OFF switch
10. BKT/OFF switch
11. DECODE/OFF/CODE switch
12. EMERGENCY 76, 77, and 4X switch-indicators
13. RADAR/OFF/MIX switch
14. DIM control
15. MUTE switch
16. M4 OVR SECT/OFF/MOM switch
17. SELECTED CONT/OFF/MOM switch
18. CHALLENGE M4 OVER indicator (Blue)
19. CHALLENGE SELECTED indicator (Blue)
20. MULTI-MODE SELECT 4 switch
21. MULTI-MODE SELECT 3/A switch
22. MULTI-MODE SELECT 2 switch
23. MULTI-MODE SELECT 1 switch
24. MULTI-MODE SELECT C switch
25. MODE 2 code switches
26. I/P OFF/X switches
27. MODE 1 code switches
28. DISPLAY DIM control
32. NTERR PWR indicator
33. MODE SEL switch

Figure 8-11.—Decoder AN/UPA-59 controls and indicators (front).



1 Intertarget data indicator
2. READ GATE/OFF switch
3. SECTOR RANGE control
4. TEST SIF/OFF/MODE C switch
5. SAL ON/OFF switch
6. SAL LO and SAL up switches
7. SAL 99+/OFF/-1K switch
8. MODE 3/A code switches
9. STRETCH/OFF switch
10 BKT/OFF switch
11. DECODE/OFF/CODE switch
12. EMERGEMCY 76, 77, and 4X switch-indicator
13. RADAR/OFF/MIX switch
14. PANEL DIM control
15. MUTE switch
16. M4 OVR SECT/OFF/MOM switch
17. SELECTED CONT/OFF/MOM switch
18. CHALLENGE M4 OVER indicator (Blue)
19. CHALLENGE SELECTED indicator (Blue
20. MODE SELECT 4 switch
21. MODE SELECT 3/A switch
22. MODE SELECT 2 switch
23. MODE SELECT 1 switch
24. MODE SELECT C switch
25. MODE 2 code switches
26. I/P OFF/X switch
27. MODE 1 code switches
28. DISPLAY DIM control

Figure 8-12.—Decoder AN/UPA-59A controls and indicators (front).

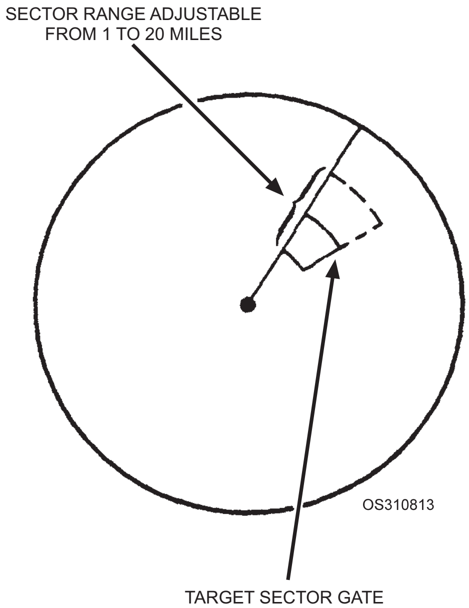


Figure 8-13.—Sector gate range.

Mode Select Switches.—MODE SELECT switches (23, 22, 21, 20, 24 on the AN/UPA-59A or B) or MODE SEL (33) and MULTI-MODE SELECT switches (20, 21, 22, 23, 24 on the AN/UPA-59) are used to select the desired modes of interrogation. These switches designate the mode(s) that will be challenged when the SELECTED challenge switch is operated.

On the AN/UPA-59, MODE SEL (33), is used to select single mode 1, 2, 3, and C challenges; dual mode combinations 1/3, 1/C, 2/3, 2/C, and 3/C; or MULTI MODE.

In the MULTI-MODE position of the MODE SEL switch, mode selections are made in the same manner as on the AN/UPA-59A and B decoders. That is, the individual MULTI-MODE SELECT switches are used to select the mode or modes to be challenged. In MULTI-MODE, the interrogations will be interlaced according to a preset pulse count selected at the interrogator front panel. For example, with a pulse count of four and modes 1 and 3/A selected, the challenge sequence will be 1111333311113333, and so forth. The code reply coming from a commercial aircraft (mode 1 lacking) challenged by such a sequence will appear as depicted in figure 8-14, view A. Gaps during which no replies were received would be normal. For the average search radar, with its relatively slow rotation rate, the associated interrogator might receive from 30 to 40 individual replies from a single transponder during one sweep of the interrogating antenna.

For mode 4 challenging, the operator will use the M4 OVR SECT/OFF/MOM switch (16) with all three models of decoder. In the SECTOR position, the M4 OVR switch (16) will challenge all targets (in mode 4 only) within the azimuth sector covered by the active area gate. The selected interrogator cannot challenge SIF modes for the duration of a mode 4 override. In the MOM position, all targets are challenged in mode 4 only as long as the switch is held in the momentary position. Valid mode 4 replies are displayed as a single slash on the PPI displays (See figure 8-15). A mode 4 target wider than 0.5 ps or brighter than other mode 4 or bracket decode (discussed later) targets should be considered invalid. Short-range mode 4 targets should not be displayed at the periphery of the PPI, so that the target width can be inspected.

The MULTI-MODE SELECT (UPA-59) and MODE SELECT (UPA-59A/B) mode 4 switches should be used only for off-the-air testing and are not authorized for mode 4 challenging except under emergency conditions. The decoder will display targets only in those modes selected at its own front panel, although the associated interrogator may be challenging in other modes also.

NOTE

The M4 OVR sector function is not range gated; therefore, the mode 4 challenge will occur in the entire azimuth sector regardless of range.

RDR/OFF/MIX switch (13). This switch is a three-position toggle switch. In the RDR position, only radar video appears on the display. In the OFF position, only IFF video appears on the display. In the MIX position, both radar and IFF video will be displayed.

DECODER PASSIVE OPERATION AND DISPLAYS

Recall from our earlier discussion that the fundamental IFF display is the code display. With the DECODE/OFF/CODE switch (11) in the CODE position, code video will be present. This includes all incoming IFF video (raw video) for any selected mode. See figure 8-14. See tables 8-1 and 8-2 for variations in switch settings for raw video display.

NOTE

Code (raw IFF) video is the only means of displaying IFF replies from a basic Mark X transponder system.

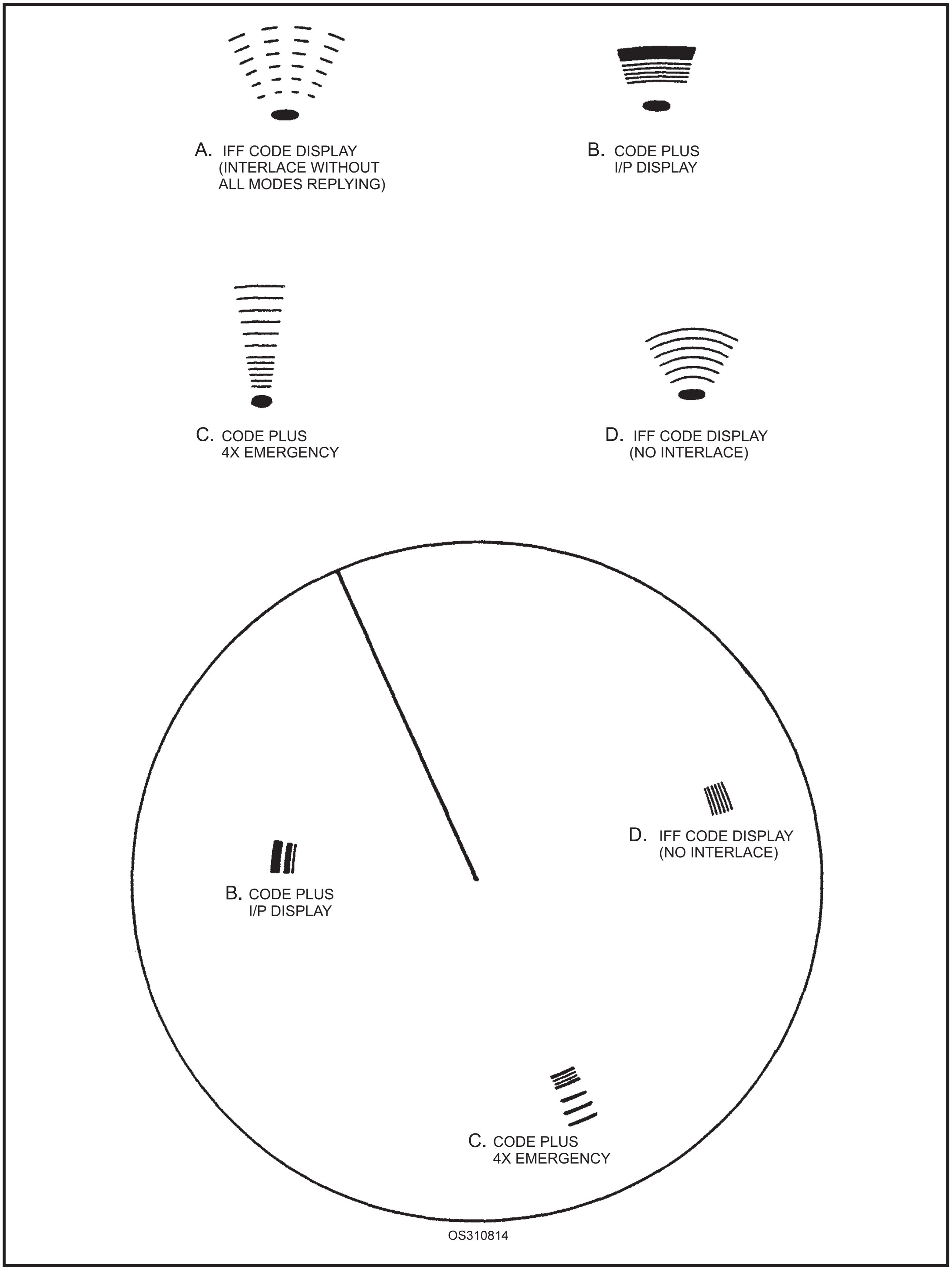


Figure 8-14.—PPI showing three different code replies: code plus I/P, IFF code, code plus 4X emergency.

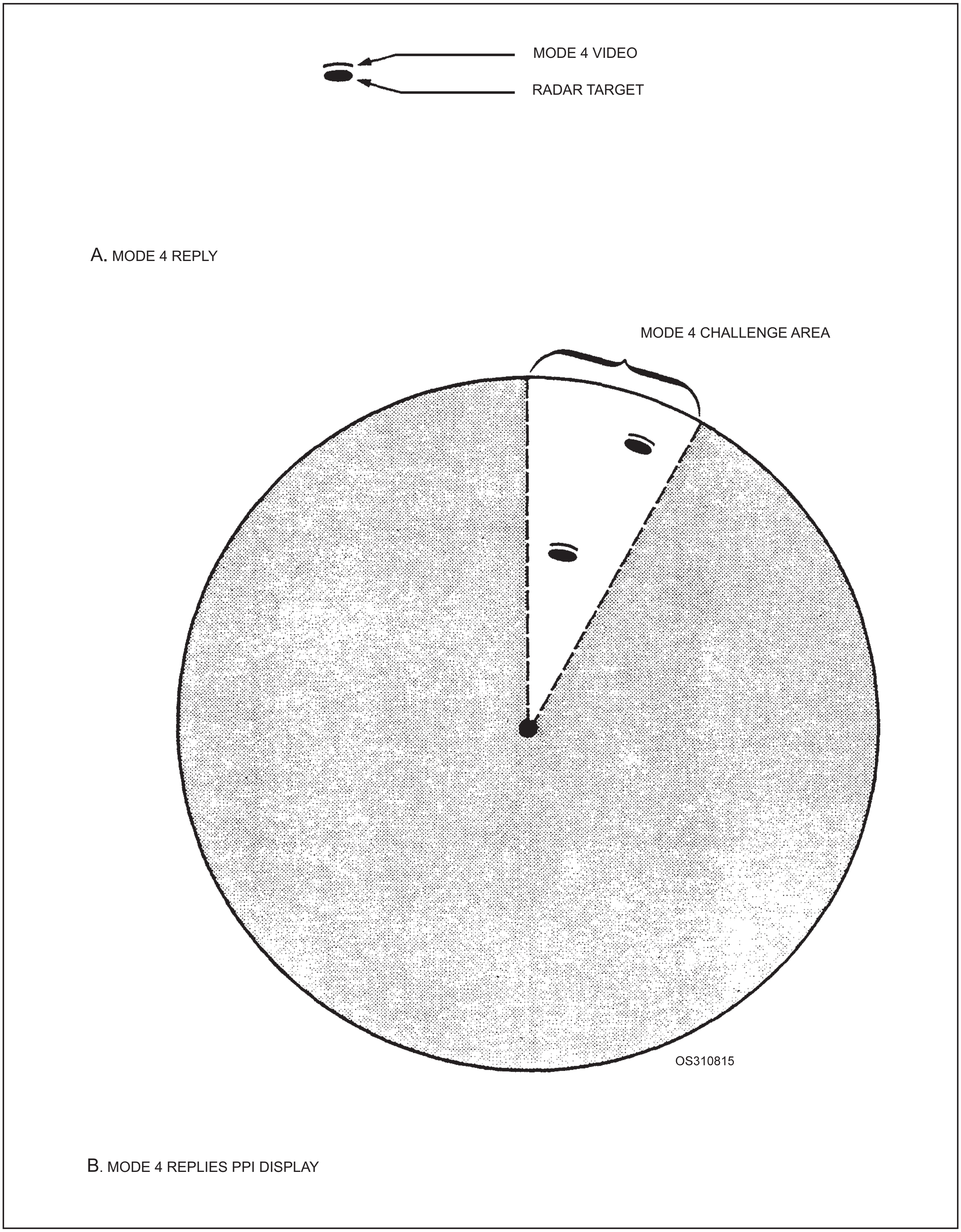


Figure 8-15.—Mode 4 replies.

Whatever its presentation format (code, decode, bracket decode, stretched video, etc.), IFF video is timed to display after radar video for the same target. The amount of this "range offset" will be determined by a number of factors. The range offset for mode 4 is always half of what it is for the other modes. The following offsets (in nautical miles) are typical.

	SIF and Mod C	Mode 4
Air Search Radars	2	1
Surface Search Radars	1	0.5
Fire Control Radars	0.5	0.25

You may choose the passive decode (no display the IFF codes) function for modes 1, 2, and 3JA operation by setting the DECODE/OFF/CODE switch (11) to DECODE. This provides a 1.0 µs single-pulse output for each mode 1, 2, or 3/A target reply, only if the reply code matches the associated MODE code switch (27) (25) (8) settings on the decoder front panel. If you need to make the code video for a specific aircraft stand out from the other video, you can stretch the passive decode pulse to 10 µs (fig. 8-16) by setting the STRETCH/OFF switch (9) to STRETCH (See figure 8-17). Mode C replies represent altitude and are not passively decoded. For certain target overlap (garbled) conditions, you may inhibit the passive decode function to keep it from being displayed.

For moderately garbled targets, you can use the active-decoding feature to extract the reply codes of targets of interest. For severely garbled targets displayed by active decoders or moderately garbled targets at passive decoders, you can manually decode IFF replies (if the PPI has an OFF-CENTER control). By alternating between the OFF-CENTER and RANGE adjustments on the display, with CODE and one mode at a time selected at the video decoder, you can display the individual reply pulses.

NOTE

> If you desire to see passive decoding of only the first two digits of the reply train, set the 12P/6P switch (rear panel of decoder) to the 6P position. For example, with 6P selected and the first two digits of the associated MODE code switches set to 64, all codes beginning with 64 will be decoded. This will happen, regardless of the value of the last two digits of the reply code or the last two digits set into the associated MODE code switches. With the 12P position selected and mode 1 enabled, only replies having a first digit 0 through 7, a second 0 through 3, and the last two digits 00 may provide passive decodes. Other codes are invalid for mode 1 and result from fruit replies in other modes. However, the requirement that the last two digits be 00 is removed for mode 1 with 6P selected. If you select the 12P position with mode 2 or 3/A enabled, all four digits of the replies will be decoded.

You may want to use the bracket decode operation for modes 1, 2, 3/A, and C. The bracket decode is a check for the occurrence of the bracket (f_1 and f_2) pulses, which frame all IFF reply code trains for the SIF modes and mode C. Positioning the BKT/OFF switch (UPA-59, UPA-59A) or BKT/OFF/ALL (UPA-59B) switch (10) to BKT will provide a single 0.4 µs pulse for all SIF and mode C replies, regardless of code content. See figures 8-18 and 8-19. In the ALL position, decoded bracket pulses for all modes being challenged by the selected interrogator will be displayed, rather than just those modes selected at that AN/UPA-59B decoder position. For certain target overlap (garbled) conditions, the bracket decode may be inhibited and not displayed.

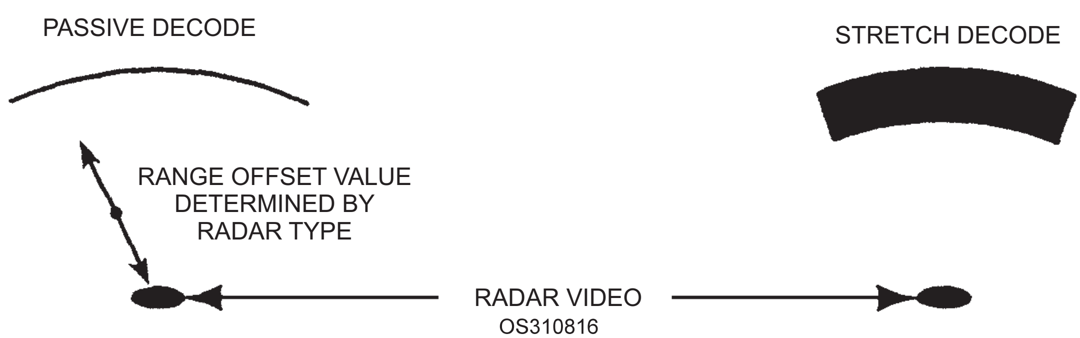


Figure 8-16.—Passive decode and stretch decode displays.

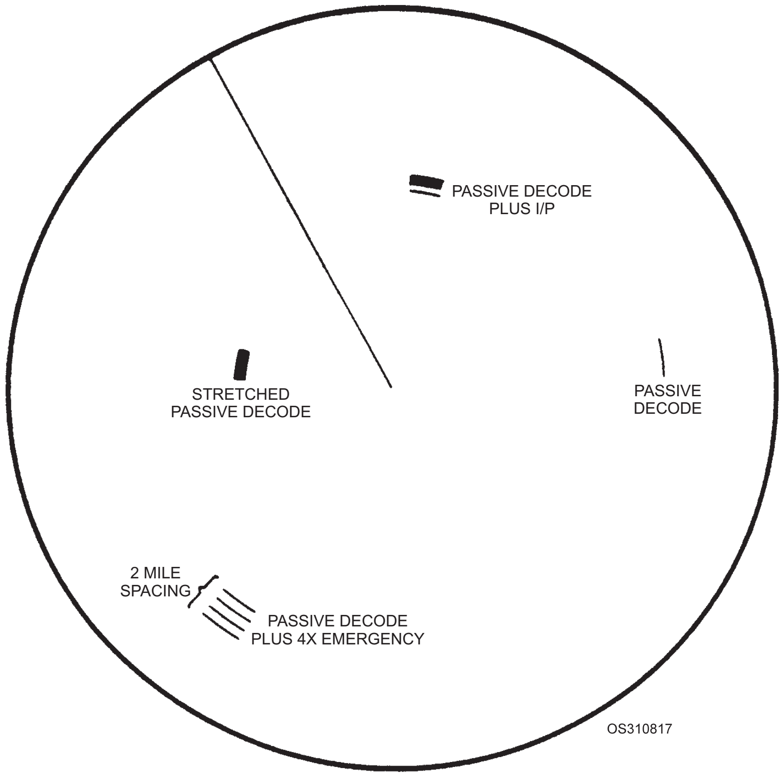


Figure 8-17.—Passive decode displays.

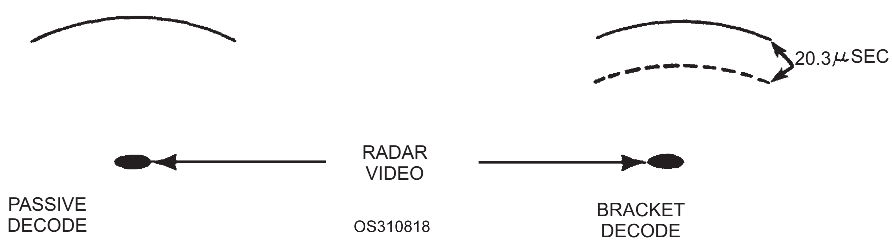


Figure 8-18.—Example showing bracket decode.

Stretched passive decoding with bracket decoding is used for displaying all valid SIF targets. This format provides a stretched pulse for replies matching the mode code switch settings and a single pulse for all other valid replies. The AN/UPA-59 and AN/UPA-59A BKT/OFF switch or the AN/UPA-59B BKT/OFF/ALL switch is positioned to BKT and the STRETCH/OFF switch to STRETCH for this feature. Figure 8-19 shows a bracket decode target and a stretched passive decode target. Mode C replies, if selected, can only be displayed as bracket decode pulses and are not stretched.

The I/P decode function is useful for identifying, on the PPI display, a particular target with which you have voice communications. Position the I/P/OFF/X switch (26) (fig.8-12) to I/P when you request an aircraft or vessel to identify its position. Refer to table 8-3 for appropriate IFF brevity codes for voice communication. This display format provides a single 20 μs stretched pulse (following each code, passive decode, or bracket decode reply as selected) for each target that is replying with the I/P code. The operator of the transponder to be challenged must manually enable I/P replies. If you select I/P, the IDENT pulse will be displayed only if one or more SIF modes are enabled. An I/P decode display will be presented to the PPI in all three positions of the DECODE/OFF/CODE switch. Refer to figures 8-14, 8-17, and 8-20 for typical I/P displays.

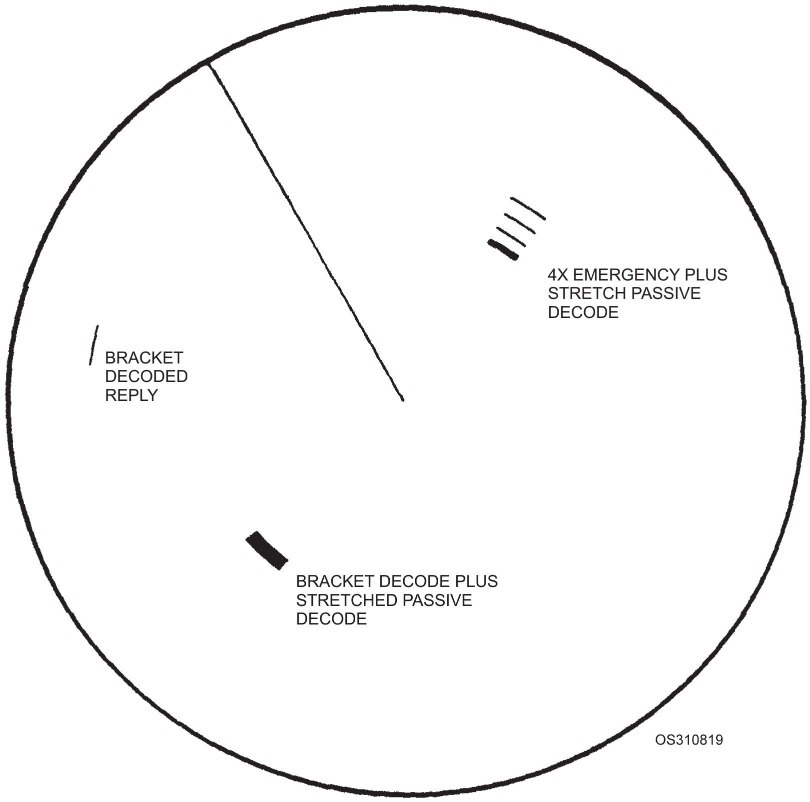


Figure 8-19.—Stretched passive decode with bracket decode.

Table 8-3.—IFF/SIF Brevity Codes

CODE	MEANING
PARROT	Military IFF/SIF transponder.
SQUAWK(ING)	Operate IFF/SIF transponder as indicated, or IFF/SIF transponder is operating as indicated.
SQUAWK ONE ( )	Turn IFF MODE 1 switch on and mode 1 code control dials to the designated setting.
SQUAWK TWO ( )	Turn IFF MODE 2 switch on and mode 2 code control dials to the designated setting.
SQUAWK THREE ( )	Turn IFF MODE 3 switch on and mode 3 code control dials to the designated setting.
SQUAWK MAYDAY	Turn IFF MASTER switch to EMERGENCY.
SQUAWK IDENT	Depress I/P switch. (Note I/P switch is spring loaded.)
SQUAWK MIKE	Turn I/P switch to MIC position. Make a short radio transmission.
SQUAWK LOW	Turn IFF MASTER switch to LOW position.
SQUAWK NORMAL	Turn IFF MASTER switch to NORM position.

Figure 8-20.—Example showing the I/P reply trains.

NOTE

In some older transponder sets, mode C replies from 30,800 feet to 94,700 feet (inclusive) may include a special position indicator (SPI) pulse. These will decode as an I/P reply if mode C is enabled. Thus, you should disable mode C whenever you are requesting an I/P reply.

The X-pulse decode format provides a single display pulse for all reply codes that contain both an X-pulse and a good code match with the associated mode's code switch settings. X-pulse replies are transmitted only from pilotless aircraft and are not present for mode C. You must know the reply code of a pilotless aircraft before you can display the reply using X-pulse decoding. X-pulse decode displays are identical to the passive decode displays of figure 8-17. To activate X-pulse decoding, position the I/P/OFF/X switch (26) to X and set the code in the selected mode's code window (27, 25, or 8). See figure 8-12.

The stretched X-pulse decode plus bracket decode provides a single pulse for all targets with bracket replies (including mode C) and a stretched pulse for targets that meet the passive decode with X-pulse requirements. The required switch settings are the BKT/OFF switch (UPA-S9/59A) or BKT/OFF/ALL switch (UPA-59B) set to BKT, the I/P/OFF/X switch set to X, and the desired codeset in the selected mode's code window. See figure 8-17 for the stretched passive decode display.

NOTE

Continue to use the numbers in parentheses to refer to the AN/UPA-59 front panel (fig. 8-11) and the AN/UPA-59A and AN/UPA-59B front panel (fig.8-12).

EMERGENCY DISPLAYS

The decoder also provides special displays to the PPI for emergency replies. In addition to video displays, when a preset number of emergency replies are received within a certain period of time, the visual and audible emergency alarms sound. When the audible alarm sounds, you can disable it by using the momentary MUTE switch (15). The alarm MUTE function is internally adjustable for a 2- to 10-second period, but the switch is usually set to 10 seconds.

When the decoder has sounded an emergency alarm, you can rapidly identify the target with the emergency by setting the DECODE/OFF/CODE switch to OFF, the BKT/OFF switch to OFF, and the I/P/OFF/X switch to OFF. With this arrangement, only emergency reply decodes will be displayed on the indicator. (Emergency reply decodes are processed by the decoder, regardless of switch settings, as long as IFF video is selected and the decoder is enabled for the mode(s) in which the emergency replies are occurring.)

The following paragraphs describe the various types of emergencies decoded and the indications the decoder provides for each type of emergency.

4X Emergency

A 4X (military only) emergency reply decodes as four pulses approximately 2 miles apart. (The 4X emergency display will be superimposed on the code display if you have selected CODE.) Only mode 1, 2, and 3/A replies may be augmented with the 4X emergency code, but this type of reply can be decoded when SIF modes are being interlaced with modes C and 4. Figures 8-14, 8-17, 8-19, 8-21, and 8-22 show 4X emergency displays; table 8-1 gives the required switch settings for this display. When the decoder detects a preset number of 4X emergency replies within a specified period of time, the 4X emergency alarm function will activate, causing the 4X indicator light on the decoder front panel to flash. The audible alarm and 4X light (12) will energize also on the alarm monitor, if installed. The 4X emergency function remains activated for 1 second after the emergency condition has ended.

7600 Emergency

The 7600 emergency reply generates three pulses approximately 1 mile apart for the display. Reply code 7600 in mode 3/A only is designated a 7600 emergency (7600 replies to modes 1 and 2 are not emergency replies). The 7600 emergency signifies a radio communication failure and can be decoded if other modes are being interlaced with mode 3/A. Table 8-1 shows the switch settings for 7600 emergency decoding. Figures 8-22 and 8-23 show the display. The

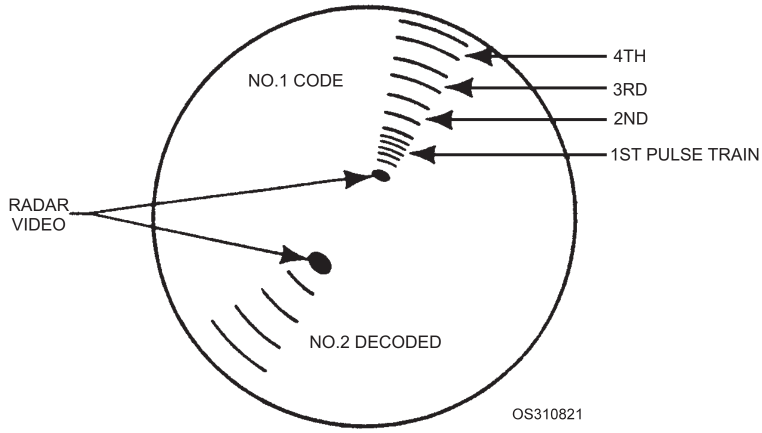


Figure 8-21.—Coded and decoded 4X emergency reply.

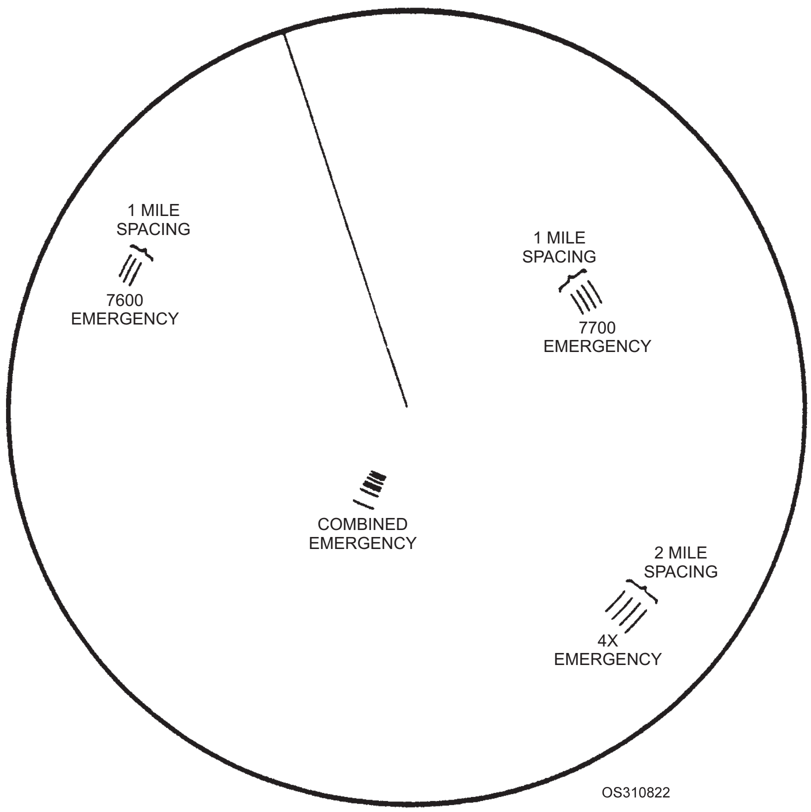


Figure 8-22.—Emergency replies.

emergency display will be superimposed on the code display if you have selected CODE. When the decoder detects a preset number of 7600 emergency replies within a specified period of time, the 7600 emergency alarm function will activate, causing the 76 indicator light (12) on the decoder front panel to flash. The audible alarm and 76 light will energize also on the alarm monitor, if installed. The 7600 emergency function remains activated for 1 second after the emergency condition has ended.

7700 Emergency

The 7700 emergency reply generates four pulses approximately 1 mile apart for the display. Only mode 3/A, code 7700 replies are designated 7700 emergencies, but this type of emergency can be decoded if other modes are being interlaced with mode 3/A. The 7700 reply for mode 3/A is a civilian emergency reply (military emergencies for mode 3/A combine the 7700 reply and the 4X reply). Table 8-1 shows the switch settings for 7700 emergency decoding. Figures 8-22 and 8-24 show the display. The

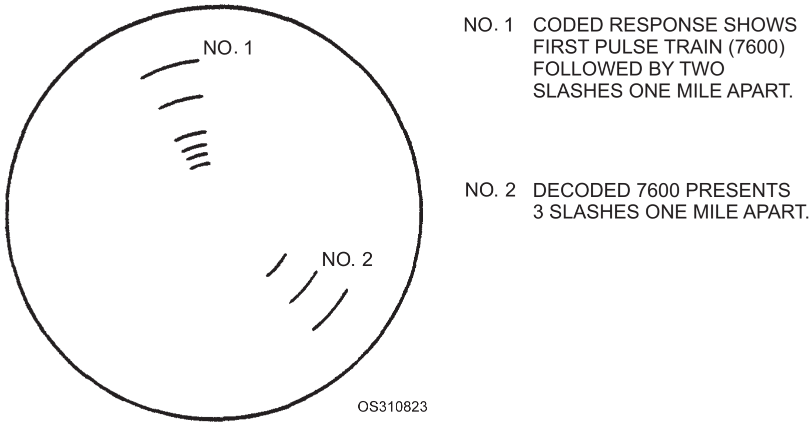


Figure 8-23.—Two examples of a 7600 emergency reply.

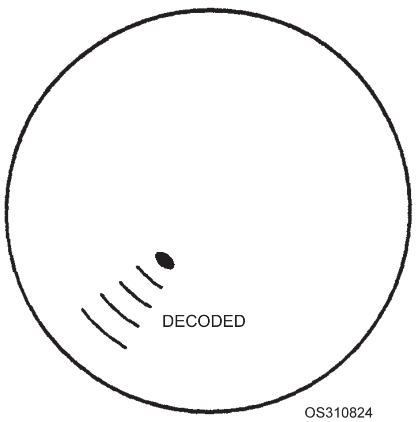


Figure 8-24.—Decoded reply of a 7700 emergency.

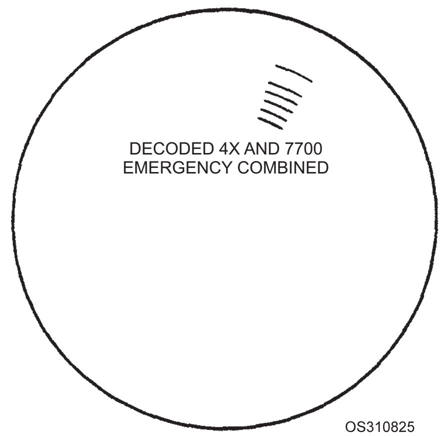


Figure 8-25.—Combined emergency.

emergency display will be superimposed on the code display if you have selected CODE. After a preset number of 7700 emergency replies are detected by the decoder within a specified period of time, the 7700 emergency alarm function will be activated, causing the 77 indicator light (12) on the decoder front panel to flash. The audible alarm and 77 light will also energize on the alarm monitor, if installed. The 7700 emergency function remains activated for 1 second after the emergency condition has ended.

Combined Emergency

A combined emergency reply is transmitted by military transponders in mode 3/A. It is a combination of the 4X and 7700 reply codes. Table 8-1 gives the required switch settings for this type of display, which consists of the 7700 and 4X emergency displays superimposed (7 additional pulses). The combined emergency reply can be decoded when other modes are being interlaced with mode 3/A. Figures 8-21 and 8-25 show examples of the combined emergency display. After a preset number of combined emergencies are decoded within a specified period of time, the combined emergency function is activated. The combined emergency function causes the 77 and 4X lights (12) on the decoder and the alarm monitor (if installed) to flash simultaneously. It also causes the alarm monitor to produce the combined tones of the 7700 and 4X emergencies. The combined emergency function remains activated for 8 seconds after the emergency condition has ended.

SELECTED ALTITUDE LAYER DECODING (SAL)

If you wish to highlight aircraft flying at a specific altitude or within a specific altitude band, use the *selected altitude layer (SAL)* decoding feature. SAL decoding allows you to specify the altitude(s) by placing settings on the UP and LO switches (6).

The SAL function operates very differently in the AN/UPA-59, AN/UPA-59A, and AN/UPA-59B decoders. To decode mode C targets, the AN/UPA-59

passive decoder must be operated in SAL bracket or SAL parity decode (discussed below). The operation of the AN/UPA-59A and AN/UPA-59B has been simplified to just a SAL decode. In SAL bracket decode, the AN/UPA-59 will not decode or display code video for other modes (this constitutes a SAL override of SIF). Table 8-1 gives the required switch settings for the SAL bracket decode and SAL decode displays. For the (V)1 configuration, the SAL bracket or SAL decode display is an effective means of determining the altitude of a target, since no active readouts are available. By varying the settings of the UP and LO switches and checking for the presence of the SAL bracket on the display, you can determine the altitude of a target to a 100-foot accuracy. You can use the “99+/OFF/-1K” switch (7) to override the lower and upper limits of SAL. When this switch is in the -1K position, the SAL is from –1,000 feet to the limit set by the UP switch. In the 99 + position, the SAL is from the LO switch setting to 126,700 feet.

MODE 4 OVERRIDE DISPLAYS

Initiating a mode 4 override from any decoder position interrupts all challenging except mode 4 for the duration of the over-ride condition. Mode 4 multi-mode operation, on the other hand, allows other modes to be interlaced with mode 4, thereby maintaining IFF video presentation to decoder positions selecting other modes. During a mode 4 override, no decoder position selecting the overridden interrogator system can present any IFF video except mode 4. Current operating policy prescribes that except under emergency conditions, mode 4 will be used in the over-ride manner. Continuous interrogation in mode 4 is prohibited because this would interfere with the routine display of targets in other modes. Once a target has been confirmed as friendly through mode 4, there is no need to re-interrogate it in mode 4 unless the track has been broken. An unknown may be interrogated several times in mode 4 and an assumed hostile should be challenged at least twice, once upon detection and again before weapons release. The two types of mode 4 override operation are described in the following paragraphs. As shown in table 8-1, you initiate a mode 4 override at the M4 OVR-SECTOR/OFF/MOM switch on the decoder front panel. This switch operates independently of other front panel switch settings.

Mode 4 Sector Override ((V)2 only)

This method of operation will display all selected modes (excluding mode 4) except during the gated sector (active area azimuth), when mode 4 alone is displayed. During the time the sweep passes through the sector, mode 4 video is displayed over the total display range, not just in the range of sector. Refer to figure 8-26. Table 8-1 gives the switch settings for this type of operation. For conventional indicator displays, the azimuth width covered by the sector remains constant as the active area is changed in position. However, for NTDS displays the azimuth width of the sector varies as the active area gate is moved in range. Mode 4 sector override operation is effective with the decoder READ GATE switch in any position. With the SELECTED switch set OFF, only mode 4 (and the sector gate) will be displayed during the sector, and no video will occur elsewhere.

Mode 4 Momentary Override

This format displays mode 4 video when the M4 OVR switch is held in the MOM position. During this time, only mode 4 is challenged by the selected interrogator. Table 8-1 gives the required switch settings for mode 4 momentary override operation. When the M4 OVR switch is released to the OFF position, challenging returns to the format determined by the mode select switches.

ACTIVE DECODING ((V) 2 CONFIGURATION ONLY)

The active decoding function of the decoder is independent of the passive decoding functions we discussed in the preceding sections. The purpose of the active readout circuitry is to provide a digital display of selected target codes and altitudes. As we explain later in this section, targets are selected for active decoding on the indicator by placing an active area window over them. The active target’s code and altitude readouts are presented on the intra-target data indicator.

Active readouts are initiated as the indicator sweep passes through the active area on the display. The intra-target data indicator channels, which read out the individual codes, hold the code display (remain lighted) for a period of time adjustable by an internal control. This readout time is usually set so the channel readouts are reset (turned off) just before the sweep completes one rotation and starts through the active area again. Thus the allowable readout time depends on

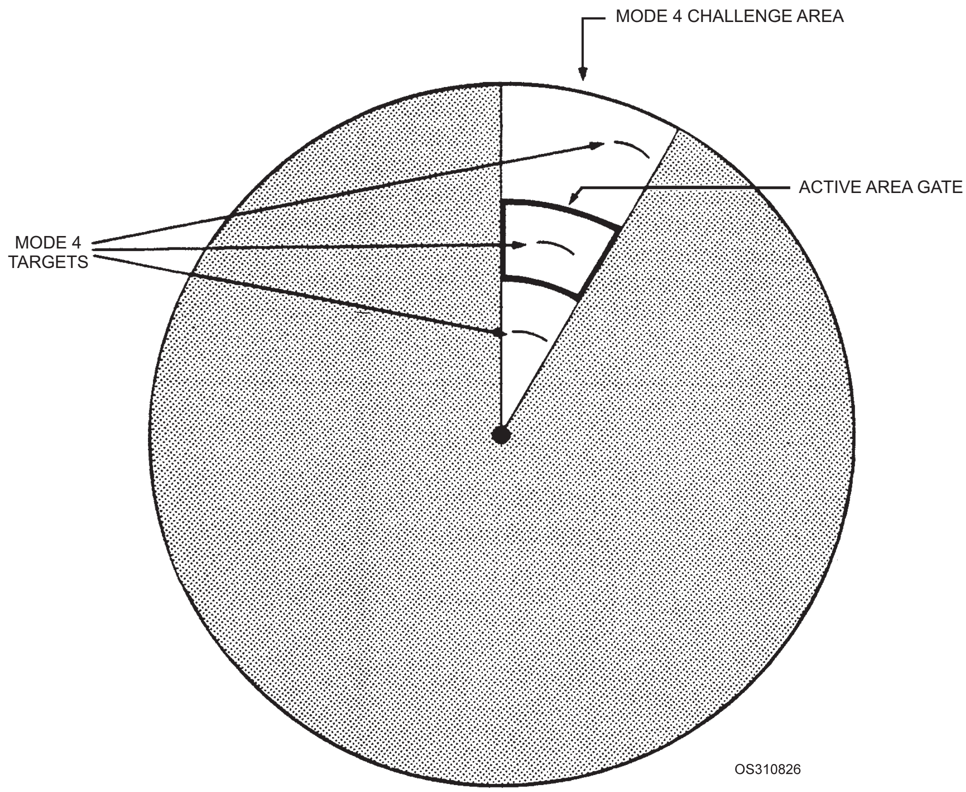


Figure 8-26.—Mode 4 video display (sector override).

antenna rpm, with lower rpm's allowing longer readout times.

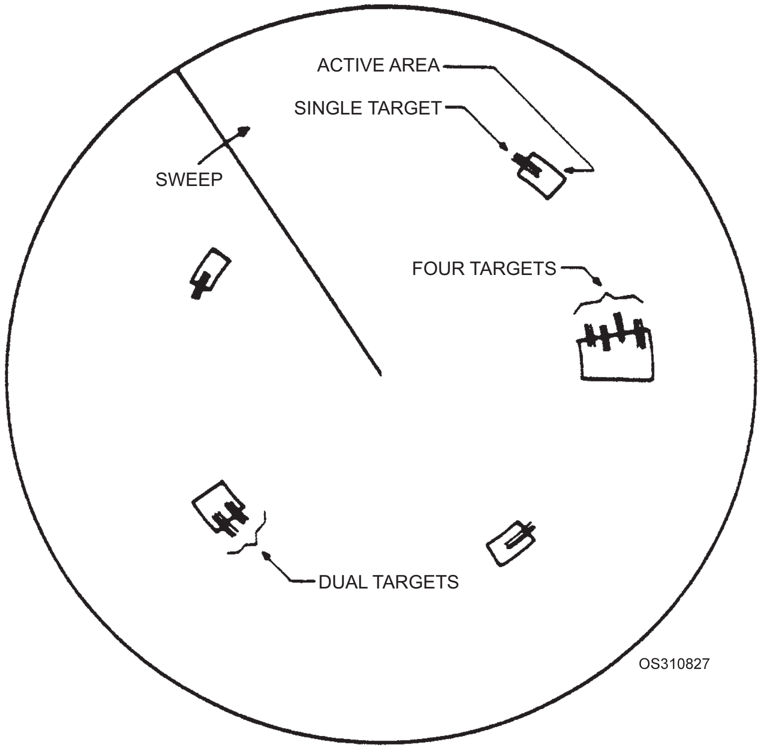
NOTE

> The AN/UPA-59B can reset the intra-target data indicator for every revolution of the antenna. If this feature is used, the readout display time will be directly related to antenna rpm and not internal adjustment. This feature is required when antenna rpm exceeds 20 rpm.

The active area presentation on a PPI will differ between conventional indicators and NTDS consoles. Operating requirements will also differ. A conventional indicator's active area is supplied to the indicator display by the decoder, having been developed from range strobe and azimuth data provided by the indicator. The conventional active area is developed in range and azimuth coordinates and is shown in figure 8-27. The NTDS active area, however, is supplied to the decoder by the NTDS console in the form of gating information. It is developed in X-Y coordinates and appears as in figure 8-28. (There are several internal link adjustments for the decoder which are set up at installation to allow operation with one or the other type of indicator.)

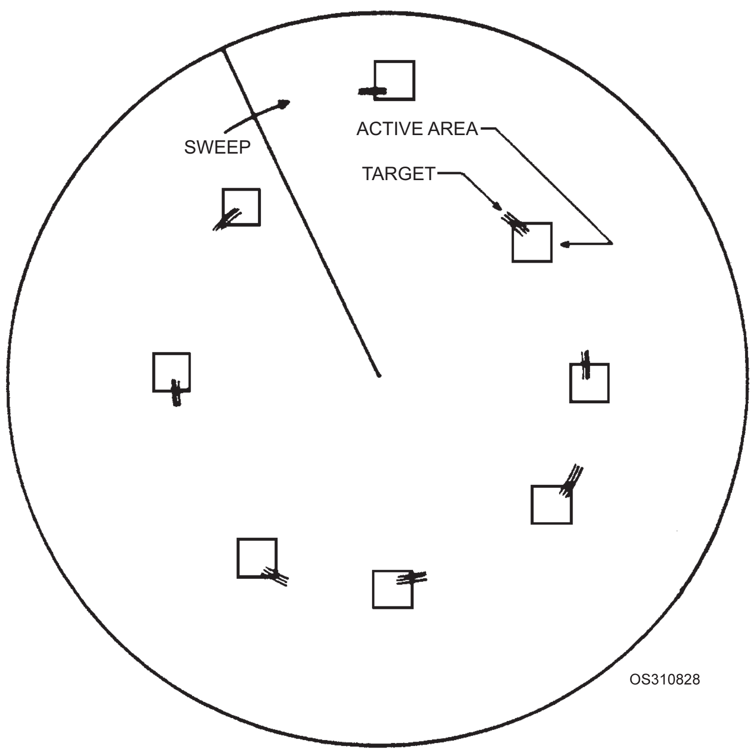
For conventional indicator presentations, you can adjust the range (length) of the active area gate from approximately 1 to 20 miles with the SECTOR RANGE potentiometer (#3 in figures 8-11 and 8-12) on the decoder front panel. See figure 8-13. Azimuth (width) adjustment is provided by an internal control. To cover the selected target(s) adequately, set the active area for conventional displays to the minimum range necessary. For decoders at NTDS consoles, set the SECTOR RANGE potentiometer to the minimum setting (full counter-clockwise), permitting the NTDS console gate-size controls to determine the size of the active area. Increasing the SECTOR RANGE control on decoders at NTDS positions would extend the active-area range, and the NTDS console controls would no longer be effective.

You can position the active area on conventional displays by using either the cursor bearing and range strobe controls or by using the "joystick" control. The bearing and range indicators on the associated PPI then depict the approximate position of the active area. The active area for conventional indicators covers a constant range length and azimuth width as its position is varied on the indicator. For NTDS consoles, however, the azimuth width covered by the active area varies with its position in the range dimension because



NOTE: ONLY ONE ACTIVE AREA WILL BE PRESENT AT ANY ONE TIME ON THE INDICATOR.

Figure 8-27.—Active area placement on conventional indicator.



NOTE: ONLY ONE ACTIVE AREA WILL BE PRESENT AT ANY ONE TIME ON THE INDICATOR.

Figure 8-28.—Active area placement on NTDS indicator.

the lengths of the sides remain constant in miles. Position the active area on the NTDS display with the ball tab control on the NTDS console.

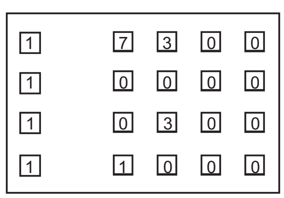
For both types of PPI, the decoder READ GATE switch (#2 in figures 8-11 and 8-12) generates an outline of the active area for presentation on the display. The switch also enables the active readout circuitry in the decoder.

For NTDS active decoding, it is good practice to place only one target in the active area at a time. When multiple targets are included, it is difficult to range correlate the readouts with the corresponding targets. However, conventional displays may include multiple targets, as we discuss in the following paragraphs.

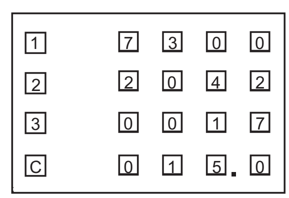
The setting of the decoder MODE SEL switch (AN/UPA-59 only) selects one of three types of programming for the channels in the intra-target data indicator as follows:

SINGLE MODE—When the active decoder is operated in single mode (except by MULTI-MODE selection), each of the four channels is programmed to read out data for the selected mode. Thus, for conventional displays where multiple targets may be processed simultaneously, up to four targets may be read out for the selected mode if they are adequately circumscribed by the active area. If all targets in the active area are intersected by the leading edge of the area gate, the target readouts will occur in range order from the top to the bottom of the indicator. See figure 8-29, view A. If fewer than four targets are being decoded, the remaining channels remain unlighted.

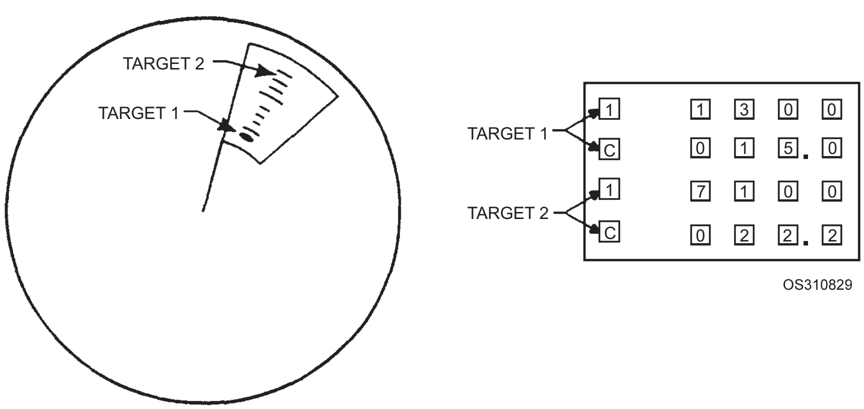
DUAL MODES—When dual modes are selected (1/3, 3/C, etc.), the first and third channels from the top of the intra-target data indicator are programmed to read out data from the first mode, and the second and fourth channels are programmed to read out data from the remaining mode. Thus, data from one or two targets may be read out. See figure 8-29, view B. (NTDS should be limited to one target in this case.). If the leading edge of the area gate is bisecting two targets and if each target is replying in both of the selected modes, the upper two channels will read data from the target at short range, and the lower two channels will read out data from the target at long range. If two targets are displayed in the area gate but only three channels of data appear on the active decoder, you cannot rely on code association with the corresponding target. The occurrence of a blank channel means that one of the targets replied in only one mode and the single readout for the missing mode is not necessarily ordered properly in range.



A. SINGLE MODE 4 TARGETS



C. MULTI MODE OPERATION



B. DUAL MODE OPERATION

Figure 8-29.—Examples of intra-target data indicator displays.

MULTI-MODE—When the MULTI-MODE position of the MODE SEL switch is selected, the four channels of the active readout are each programmed to read one particular mode. (See figure 8-29, view C). The top channel displays only mode 1 data, the second only mode 2 data, the third only mode 3/A data, and the bottom channel only mode C data. If any modes are not enabled or if a selected target is not replying to a particular mode, the channels for these modes will remain unlighted. For multi-mode operation (conventional or NTDS displays) only one target should be actively decoded at a time. If you attempt active decoding for more than one target in multi-mode operation, you will find it impossible to associate the readouts with the proper target.

The setting of the MODE SELECT switches for AN/UPA-59A and B decoders selects one of three types of programming (single, dual, or multi-mode) for the channels in the intra-target data indicator. The readout is essentially the same as described above for single mode, dual mode, and multi-mode operation of decoder group AN/UPA-59.

Since active decoding for NTDS displays involves single targets, only the top channel will be used in single-mode operation. For dual-mode operation, only the first two channels will be used. Multi-mode operation for NTDS displays is identical to that for conventional displays.

Proper placement of the active area over targets is an important factor in maintaining the validity of the active readouts. Figure 8-27shows recommended area gate placements for targets at various positions on conventional indicators. Single targets should be bisected simultaneously by the leading edge of the area gate or else gated separately. When multiple targets are not all cut by the leading edge of the gate, even though they may be contained within the gate, the probability of an invalid readout is increased. The NTDS active area should be placed so that the target is bisected by the leading edge of the gate, as shown in figure 8-28, reducing the possibility of fruit readouts.

A correlation link is provided internally for the decoder. With correlation selected, a target reply code for a given mode must be present on two consecutive interrogations for the code to be displayed on the active readout. This further reduces interference from fruit replies.

Active degarbling occurs for all active readouts. When two replies overlap (garble condition), the active readouts will be inhibited.

Q3. What transponder control set is used to set in modes 1 and 3/A reply codes?

Q4. What does a mode 4 emergency code reply look like on a radar scope?

OPERATION UNDER JAMMING AND EMERGENCY CONDITIONS

The IFF system has several anti-jamming features and will be enhanced with more of these in the years ahead. The decoder contains special circuitry to reduce jamming caused by constant transmission of signals known as *reset tags*. Only the AN/UPA-59 decoder is susceptible to reset tag jamming, and this is being corrected with a field change entitled “P1 Reset”. The interrogator set has anti-jam circuitry, which you can activate by placing the interrogator set front panel ANTI-JAM ON/OFF switch in the ON position. A field change entitled “Anti-Jam Receiver” will operate automatically and reduce more types of jamming signals. When this field change is installed, the ANTI-JAM switch will remain in the ON position. Also, a JAM indicator will be installed on Control-Monitor C-8430/UPX. Under most types of jamming, the decoder should be operated in the CODE display format for best results. However, the type of jamming that is present will determine which methods of decoder operation are reliable.

The following paragraphs describe the various emergency conditions you may encounter and the actions you must take to overcome them.

Normally, the decoder gets its primary power from the interrogator set. If something interrupts this power, you can restore power to the decoder by setting the decoder rear panel LOCAL/OFF/INTERR switch to the LOCAL position. This allows decoder primary power to be controlled at the decoder, not by the interrogator set. If there is a total power failure to the decoder group, radar video will be supplied to the PPI by means of a bypass relay.

If the decoder’s remote enable lines to the interrogator set (via a switchboard, as in figure 8-1) fail, the LOCAL/REMOTE switch on the front panel of the interrogator can be set to the LOCAL position. This allows you to select modes locally by using the interrogator MODE SELECT and CHALLENGE switches. With the interrogator switched to LOCAL, the desired IFF modes must still be selected at each decoder position to enable the decoder to function properly. With LOCAL control selected at the interrogator set, the GTCLONG/SHORT switch on the

interrogator set front panel controls the receiver GTC function. Remote control of this parameter is removed from the control-monitor, C-8430/UPX.

If the enable circuits are only partially lost, the interrogator set may be enabled from any functioning decoder position. However, the desired modes must still be selected at the decoder whose enable lines failed, in order for decoded displays to be programmed properly. If control lines other than MODE SELECT and CHALLENGE SELECTED are lost, IFF presentation will be at a reduced capability (e.g., code video only) or lacking altogether (radar video only).

MODE 4 SYSTEM OPERATION

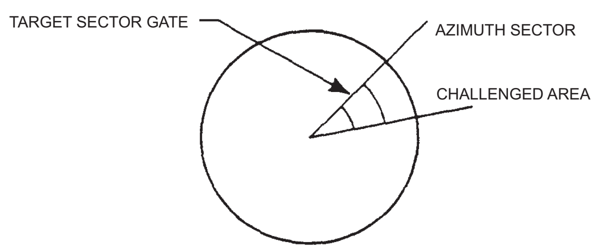
Directive instructions on the use of mode 4 are provided in ACP 160 US Supp 1(C) (chapter 1, paragraphs 102 and 104, and chapters 3 and 5), which is recommended for further reading. For units operating with NATO forces, appropriate paragraphs from chapters 1 and 2 of ACP 160 NATO Supp-l(C) apply.

Mode 4 interrogations may be enabled in either of two ways: interlacing or overriding

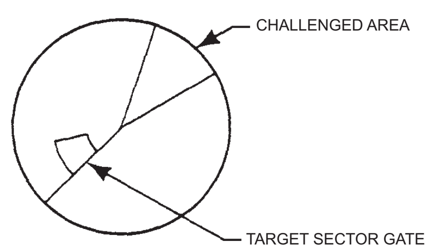
Mode 4 interrogation used to be enabled as part of a mode interlace sequence that would challenge mode 4 on every other change of mode. For example, if modes 1, 2, 3/A, and 4 were selected with a pulse count of 2, the challenge sequence would be 44-11-44-22-44-33-44. Interlace sequences and pulse counts are selected at the front panels of interrogators. Current policy prohibits this method of mode 4 use because of difficulties arising from continuous mode 4 interrogation (ATCRBS interference and signal security considerations). The approved switch settings for the interrogator set will disable the MODE SELECT/4 switch (20) on the decoder front panel.

Currently, all mode 4 challenging must be done using the mode 4 override function. Whenever the mode 4 override is enabled, the selected interrogator system will challenge mode 4 only, regardless of other modes that may be enabled (at any decoder linked to that interrogator system).

Mode 4 override may be selected in sector or momentary modes. A sector override operates continuously throughout the azimuth of the sector gate. See figure 8-30, view A. A momentary override operates only as long as the M4 OVR switch is depressed in the MOM position. See figure 8-30, view B. When you make MOM override interrogations,



A. SECTOR: CHALLENGED TARGETS FALL WITHIN A SECTOR DETERMINED BY WIDTH OF TARGET SECTOR GATE.



B. MOMENTARY: CHALLENGED AREA SHOULD NOT EXCEED 30 DEGREES OF AZIMUTH.

OS310830

Figure 8-30.—Example of the mode 4 override operation.

limit them to sectors of about 30 degrees for systems having slow and medium antenna rotation speed. Systems having high antenna rotation speeds, like the Mk 92 radar, require a larger sector to achieve an observable mode 4 display.

When a transponder receives mode 4 challenges, the KIT-lA/TSEC computer decodes the encrypted word. If it detects an invalid challenge, it sends a disparity pulse to Receiver-Transmitter RT-859A/APX-72. When the computer makes a valid mode 4 reply decision, it generates the appropriate reply and sends it to the receiver-transmitter unit for transmission. A transmission signal sample is used to light the REPLY lamp on the Transponder Set Control C-6280A/APX, when the AUDIO-OUT-LIGHT switch is in the AUDIO or LIGHT position. A disparity signal from the KIT-lA/TSEC will inhibit the transmission of a reply. If neither a disparity pulse nor a reply transmission follows the reception of a valid mode 4 interrogation, the MODE 4 CAUTION light on the CY-6816/APX-72 will illuminate. If this situation occurs, check the equipment for a malfunction or improper switch settings. When the MODE 4 CAUTION light illuminates constantly, the causes may be an inoperative KIT-lA/TSEC, an improper mode 4 code, or no code at all loaded into the KIT-lA/TSEC. The MODE 4 CAUTION light will not illuminate if the wrong day's code is loaded into the computer or if the mode 4 CODE A/B switch on the C-6280A(P)/APX is in the wrong position.

Control Monitor C-8430/UPX Mode 4 Operation

The control-monitor provides the following controls and alarms for mode 4 operation:

VERIFICATION BITS (1 and 2) (two switches).—Both switches have two positions, marked NORMAL and TEST. They are usually set to the NORMAL position. If you need to differentiate a target previously identified in mode 4 from other mode 4 targets, move the Bit 1 switch to the TEST position and have the target squawk RAD TEST. Verify bit number 2 is not used at this time.

CODE A/B Select.—Each code table loaded into a crypto computer consists of two separate variables: code A is for the current crypto period and code B for the following crypto period. Normally the code select switch is set to A. However, should the ship's operations or a maintenance problem preclude loading the next key extract at the required time, you may place the CODE SELECT switch in the B position. This will allow you to continue operations with crypto-secure identification since the proper day's code will be enabled within the computer.

CAUTION

Operation in code B prior to the designated crypto period is a security violation. If you have to operate in code B, have the operation reported to the CMS officer, who will notify the National Security Agency (NSA).

ZEROIZE Control and Alarm.—The settings of the ZEROIZE/ALARM switch are NORMAL and ZEROIZE, with the usual operating position being NORMAL. When the switch is in the NORMAL position, the ZEROIZE ALARM is deenergized. Moving the switch to the ZEROIZE position will dump (remove) the code from the crypto computer and energize the ZEROIZE ALARM indicator. This switch has a hinged cover to prevent accidental zeroizing.

LOCKOUT OVERRIDE and Alarm.—The settings of the LOCKOUT OVERRIDE switch are NORMAL and LOCKOUT OVERRIDE, with the usual operating position being NORMAL. During a lockout condition, (KIR-lA/TSEC crypto computer malfunctions) the LOCKOUT ALARM indicator light will be energized. If the tactical action officer determines that mode 4 must continue to operate under such circumstances, you may override the KIR-lA/TSEC lockout by placing the switch in the OVERRIDE position. This may or may not restore mode 4 interrogation capability. If you must operate in the OVERRIDE position, have the operation reported to the ship's CMS officer as a potential security violation. The override is also protected with a switch guard to prevent accidental operation.

Control Enclosure CY-816/APX Mode 4 Operation

The CY 6816/ enclosure houses the Transponder Set Control C-6280A(P)/APX-72. The enclosure contains the MODE 4 CAUTION lamp and its test switch, which is marked TEST/NORMAL. The switch is spring-loaded and assumes the NORMAL position by itself. When the switch is held in the TEST position, the lamp socket is energized for testing the light bulb. With the switch in the NORMAL position, illumination of the MODE 4 CAUTION lamp will indicate a failure or improper operation of the transponder set. Although we discussed some of the

causes of a MODE 4 CAUTION indication earlier, we provide a brief summary below.

1. TRANSPONDER SET CONTROL CAUSES OF CAUTION LIGHT ACTIVATION

   a. The MASTER switch is in STBY (standby) when the transponder is receiving valid mode 4 interrogations.

   b. The MODE 4 ON/OUT switch is in the OUT position when the transponder is receiving valid mode 4 interrogations.

   c. The CODE switch is in the ZERO position (this dumps the code from the computer).

2. TRANSPONDER CRYPTO COM PUTER CAUSES OF CAUTION INDICATION

   a. There is no 115V ac power to the computer.

   b. An invalid code has been inserted.

   c. There is no code in the computer or the computer is dismounted.

   d. The computer's automatic self-test function detects a fault.

NOTE

A wrong day's code in the computer will NOT cause the CAUTION lamp to light.

3. RECEIVER-TRANSMITTER CAUSES OF CAUTION LIGHT ILLUMINATION

   a. A receiver-processor is misaligned or a transmitter has failed.

   b. The CAUTION light circuit has failed.

Transponder Set Control C-628OA(P)/APX and C-10533/APX-100 Mode 4 Operation

The transponder control unit provides the following controls and indicators for mode 4 operation:

CODE Switch.—The CODE switch, a four-position switch, is the master control for code selection and retention. This switch allows you to selection codes A or B or the code ZEROIZE function for the KIT-lA/TSEC transponder computer. Normally the CODE switch is operated in the code A position. The ZEROIZE position of the switch causes the computer to dump (remove) its code. The HOLD position is used only in aircraft installations and allows code to be retained when power is removed. The HOLD position is not operative in shipboard installations.

REPLY Indicator.—If the AUDIO/OUT/LIGHT switch is in the AUDIO or LIGHT position, this indicator lights when the receiver-transmitter transmits replies to a valid mode 4 interrogation. It also lights when pressed for the lamp self-test function.

MODE 4 Switch.—In the ON position, the MODE 4 switch enables the KIT-lA/TSEC computer to process and reply to mode 4 interrogations. In the OUT position, it disables computer operation. Additionally, a TEST in the OUT position is found on the C-10533/APX-100, allowing for mode 4 self-test of the transponder set. This mode 4 self-test function works in conjunction with the TEST GO and TEST/MON NO GO indicators. The KIT indicator may also illuminate when mode 4 fails self-testing on the AN/APX-100 transponder set.

AUDIO/OUT/LIGHT Switch.—In the AUDIO position, the switch enables both AUDIO and REPLY light monitoring of mode 4 transponder replies. AUDIO monitoring is seldom used on shipboard installations. In the LIGHT position, the switch enables only the REPLY light to monitor mode 4 replies. This is the recommended switch setting. In the OUT position, the switch disables both AUDIO and REPLY light monitoring of mode 4 transponder replies.

RAD TEST/OUT/MON Switch.—When held in the RAD TEST position (momentary), this switch enables the transponder to reply with a mode 4 form of identification of position (I/P). This works in conjunction with VERIFICATION BIT 1 selection on the Control Monitor C-8430/UPX. Push the switch to this position only on the request, by voice communication, of an interrogating ship or aircraft. Otherwise, RAD TEST will invalidate the code loaded into the KIT-lA/TSEC computer, preventing replies to mode 4 interrogations. With the switch in the MON position (C-6280A(P)/APX only), the monitor circuits of test set TS-1843/APX-72 are enabled (not applicable to mode 4 replies), and the TEST light is energized if reply parameters are normal. In the OUT position, the switch disables the RAD TEST and MON modes of operation.

TEST GO Indicator (C-10533/ APX- 100 only).—A valid reply during mode 4 self-testing will light this indicator. The lamp also has a press-to-test feature.

TEST/MON NO GO Indicator (C-10533/APX-100 only). Failure of the mode 4 self-test to produce a valid reply illuminates this indicator. The lamp also has a press-to-test feature.

STATUS KIT (C-10533/APX-100 only).—This indicator energizes during mode 4 self-test to signal a KIT-lA/TSEC problem.

Crypto Computers KIR-lA/TSEC and KIT-lA/TSEC

The KIR-lA/TSEC interrogator computer provides mode 4 encoding and decoding for the interrogator. It encodes challenges to be transmitted by the interrogator and decodes transponder replies for display on the radar indicator. The operator may select either of two preset codes with the CODE A/B select switch on Control-Monitor C-8430/UPX in CIC. The KIR-1A/ TSEC is loaded through its code changing assembly. The keying variables, codes A and B for two successive crypto periods, are first set manually into the KIK-18/TSEC keyer. The keyer is then inserted into the code changer assembly of the computer. When the keyer is removed and the code changer access door is closed, the code is set.

The mode 4 transponder computer's operation is controlled by Transponder Set Control C-6280A(P)/APX-72, located in CIC. The KIT-lA/TSEC computer is also loaded, in the same manner as the KIR-1A/TSEC computer, through its code changing assembly.

The code is usually set in the KIK-18/TSEC crypto code keyer in the same area where the key lists are secured. The approved method is to have two people load the keyer; one reads the code while the other loads the code into the keyer. After the loading is completed, the code is verified, with the two people reversing positions and reading the code again. With each pin correctly positioned, the two keys, code A and code B, covering two successive crypto periods, are ready for loading into the computers. The operational codes are listed in the current edition of the AKAK 3662 key list. The AKAK 3662 does not have an official title but is referred to simply as the mode 4 "operational code" or "code of the day".

CAUTION

The KIK-18/TSEC keyer is unclassified when zeroized but becomes CONFIDENTIAL with a code loaded into it.

Mode 4 replies are displayed on the display unit as single slashes similar to bracket decoded replies. Long- and medium-range detection systems normally display mode 4 video 1 mile behind radar video. Short-range systems display the mode 4 video 1/2 mile or less behind radar video. See figure 8-25.

IFF OPERATIONS BREVITY CODES

For voice communication with military craft, a set of standard brevity codes has been established by an Allied Communication Publication (ACP 160A). These voice codes enhance IFF operation, permitting the rapid identification of aircraft under control of ships and the communication of IFF equipment operating status. See tables 8-3 and 8-4.

Q5. How is a Mode 4 challenge initiated?

Table 8-4.—Mode 4 Brevity Codes

CODE	MEANING
SQUAWK FOUR	Turn MODE 4 switch on.
CHECK SQUAWK FOUR	Ensure emitting current crypto period key setting.
STRANGLE FOUR	Turn MODE 4 switch off. Continue squawking other applicable modes.
NEGATIVE SQUAWK FOUR	MODE 4 interrogation/reply not received.
SQUAWK FOUR BENT/SOUR	MODE 4 inoperative/malfunctioning.
IDENTIFY SQUAWK FOUR	Reidentify target/hostile aircraft.

ANSWERS TO CHAPTER QUESTIONS

A1. An interrogator subsystem and a transponder subsystem.

A2. Mode C. Altitudes range from -1,000 feet to + 126,700 feet in 100-foot increments.

A3. Transponder Set Control C-6280A(P)/APX.

A4. Four pulses, approximately 2 miles apart.

A5. By using the mode 4 override function.

CHAPTER 9

DEAD-RECKONING SYSTEMS

LEARNING OBJECTIVES

After you finish this chapter , you should be able to do the following:

1. Identify the equipment associated with the ship's dead reckoning systems and state the purpose of each piece of equipment.
2. Discuss how to operate the DRT, under both normal and casualty condition
3. Describe geographic plotting procedures including direct plot, indirect plot, determining contact course and speed and man overboard procedures.

INTRODUCTION

Dead reckoning (DR) is probably the oldest form of navigation. This method of determining a ship's position considers only the ship's course and speed over a specified period of time, ignoring the effects of wind and current. Although certainly not an exact or precise form of navigation, dead reckoning provides valuable data from which to establish a true position. It is also useful in planning and executing tactical maneuvers.

In this chapter, we will discuss the basic equipment and procedures used to perform DR navigation.

DEAD-RECKONING EQUIPMENT

The primary equipment used for DR navigation consists of the dead reckoning analyzer indicator (DRAI), the gyrocompass, the underwater log, and the dead-reckoning tracer (DRT).

DEAD RECKONING ANALYZER INDICATOR

One dead-reckoning system is the Dead Reckoning Analyzer Indicator (DRAI), figure 9-1. The DRAI is an electrical-mechanical computer that receives inputs of own ship's speed from the underwater log (pitometer log) (fig. 9-2) and own ship's course from the master gyrocompass (fig. 9-3). The DRAI uses these two inputs to compute the ship's position (latitude and longitude) and distance traveled. The computed position and distance traveled are displayed on counters on the DRAI's front panel. The ship's course and speed inputs also are transmitted to the plotting system.

GYROCOMPASS

The basic navigation compass is the *magnetic* compass. While the magnetic compass is accurate, it has two important drawbacks for use in long-distance navigation. First, the magnetic North Pole is located some distance from the true North Pole. In general, because the true and magnetic North Poles are not located at the same geographic spot, a magnetic compass needle points away from true north. Since navigation charts are based on true north, magnetic directions are slightly different from true directions. The amount the needle is offset from true north by the Earth's magnetic field is called variation.

The second drawback of a magnetic compass is that its needle is deflected by magnetic materials in the ship and by magnetic materials brought near the compass. The amount a magnetic compass needle is deflected by magnetic materials in the ship around it is called deviation.

To eliminate the directional problems associated with magnetic compasses, ships use a *gyrocompass* for primary navigation. The gyrocompass, unaffected by either variation or deviation, points constantly to true north. For DR purposes, the gyrocompass sends course information to the DRAI, where it is combined with data from the pitlog and is broken down into

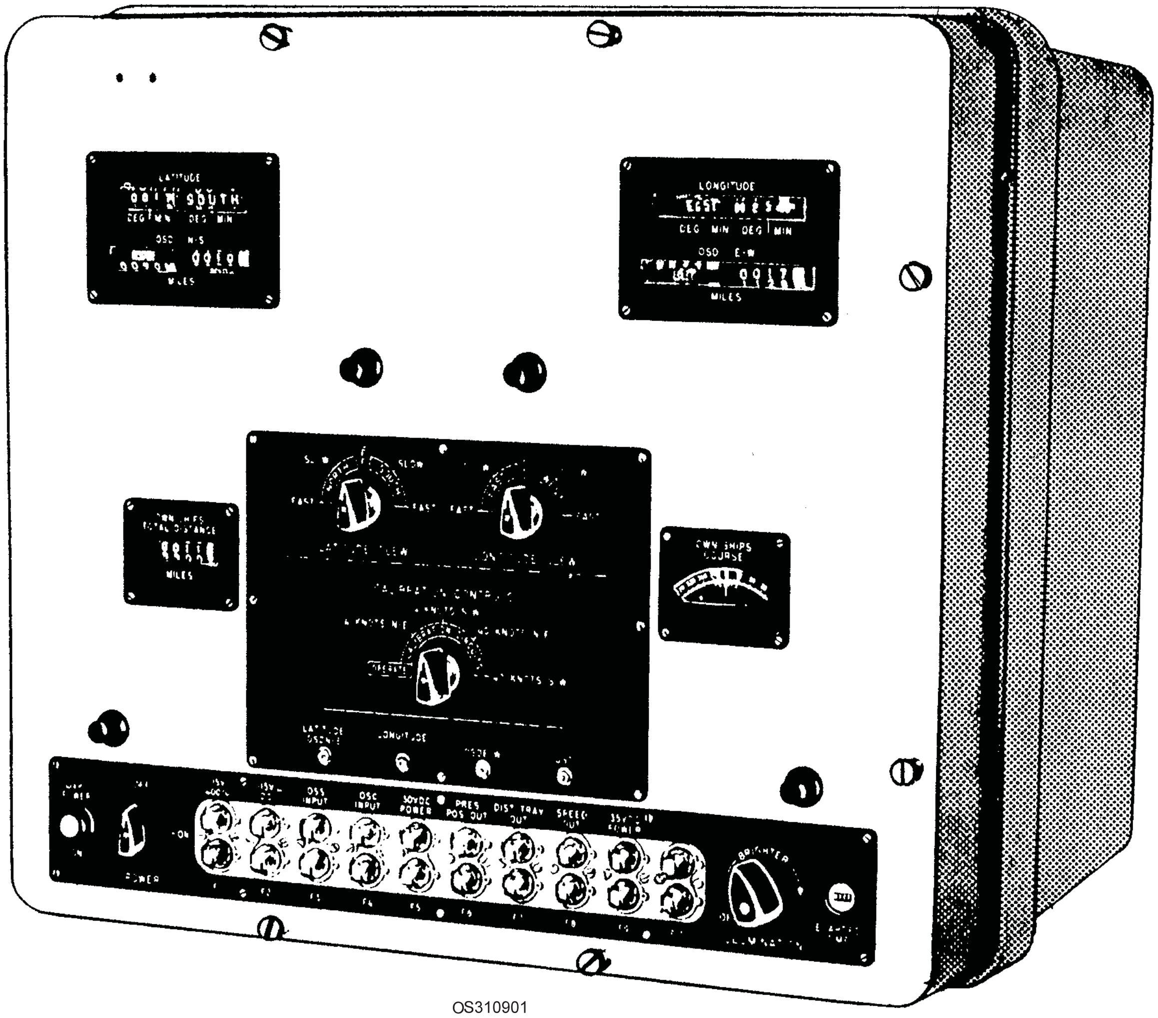


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Figure 9-1.—DRAI Mark 9 Mod 0.

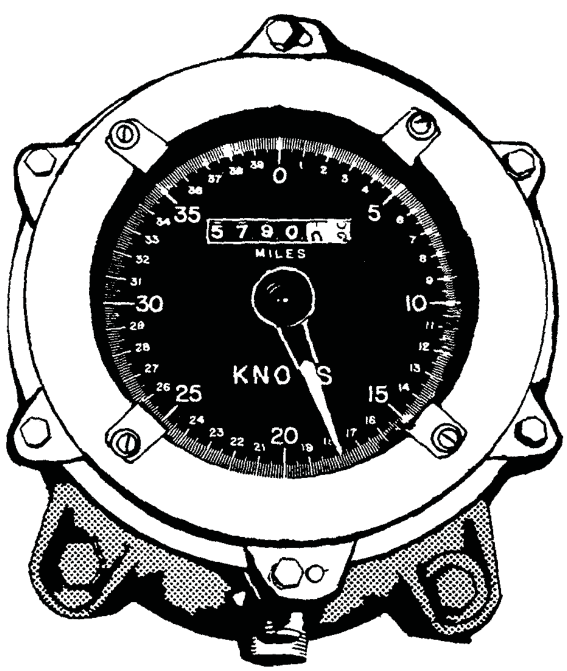

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Figure 9-2.—Pitlog Indicator.

components of travel in north-south and east-west directions.

Despite the proven dependability and reliability of the gyro mechanism, however, the magnetic compass is the standard compass found aboard ship. This is because the gyrocompass is powered by electricity. If the electrical supply is lost, the gyro becomes useless. Also, because the gyrocompass is a complicated and delicate instrument, it is also subject to mechanical failure. Because the DRAI receives its input from the gyrocompass, any casualty to the gyrocompass affects the DRAI outputs to plotting equipment.

UNDERWATER LOG SYSTEM

The underwater log system (called pitlog or electromagnetic log) measures the ship's speed and the distance traveled. It transmits these indications to the speed and distance indicators and to the weapons and navigational systems.

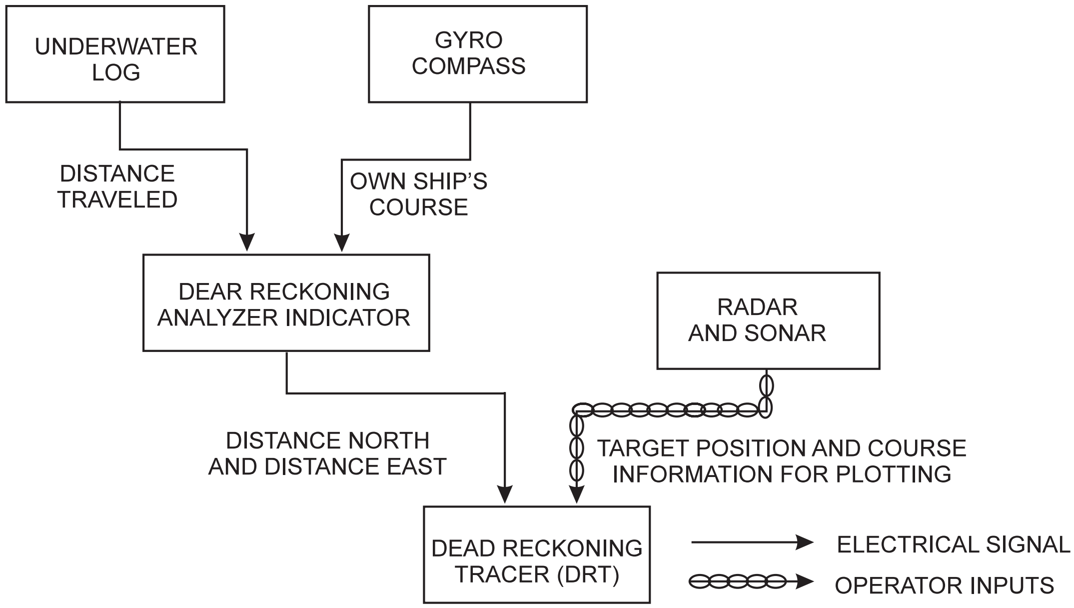

Figure 9-3.—Dead-reckoning system, simplified block diagram.

Sometimes, simulated speed and distance signals are needed for the various DR systems. In these instances, the *dummy log system* supplies such inputs. This system serves two purposes: (1) to simulate ship's movement through the water (for training personnel and aligning equipment) and (2) to serve as a backup for the underwater log system.The majority of all current underwater log systems use the electromagnetic principle to sense the ship's speed. Several different configurations using this principle of operation have been produced by various manufacturers for the Navy.

The electromagnetic principle is the same basic principle by which a generator produces a voltage. If a conductor is moved through a magnetic field, a voltage will be induced in the conductor. The magnitude of the induced voltage will vary with the number of active conductors moving through the magnetic field, the strength of the magnetic field, and the speed at which the conductor is moved through the magnetic field. An increase in the number of conductors, the strength of the magnetic field, or the speed of the conductor through the field will result in an increase in induced voltage.

The electromagnetic underwater log functions by placing a magnetic field in seawater. Seawater conducts electricity very well and is used as the conductor. When the ship is not moving through the water, there is no relative motion between the magnetic field and the conductor; therefore, no voltage is induced in the conductor (seawater). As the ship begins to move, relative motion takes place and a voltage is induced in the seawater. An increase in the ship's speed increases the induced voltage at a rate directly proportional to the increase in speed. By comparing the induced voltage to a known voltage, the system makes an accurate determination of the ship's speed.

DEAD RECKONING TRACER (DRT)

The dead reckoning tracer (DRT) (fig. 9-4) is basically a small table with a glass top, on which the ship's true course is plotted. The DRT operator places a piece of tracing paper on top of the glass and periodically marks lighted ship positions projected onto the paper from beneath the glass.

The DRT operates automatically from input signals from the DRAI. The east and north components, after setting the proper scale, drive the lead (E-W) and cross (N-S) screws to move the bug across the plotting surface. Figure 9-4 shows the location of the lead screw and the cross screw. A switch is provided for rotating the tracking axis 90°. Latitude and longitude are continuously computed from the two inputs and displayed on counters in the control compartment.

Figure 9-5 illustrates the operating controls and indicators of the Mk 6 Mod 4B DRT. Refer to the figure as you review the following list of controls and their functions.

Lamp (1): Provides illumination for the control compartment.

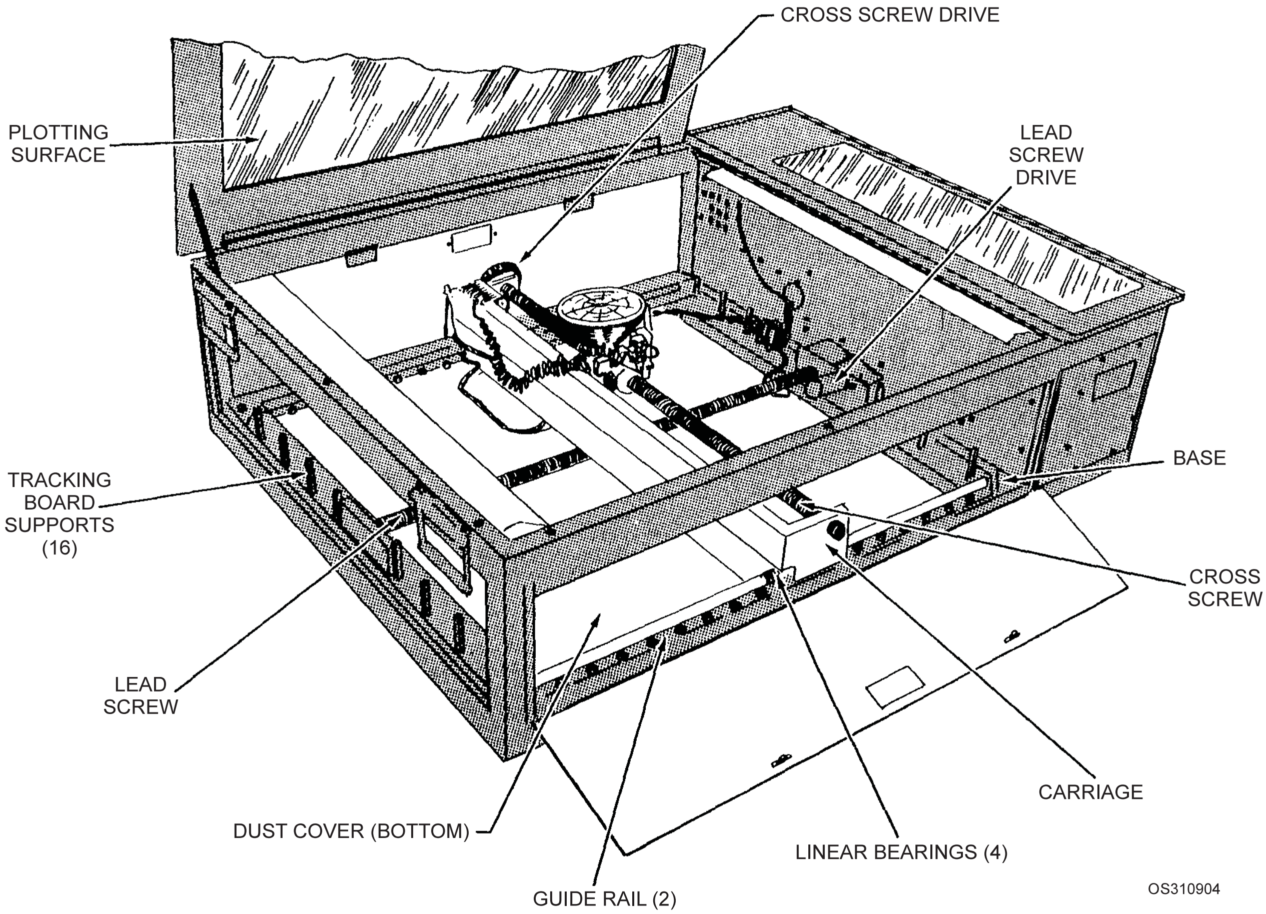

Figure 9-4.—DRT, opened.

Illumination (2): Controls the intensity of the lamps in the tracing and control compartments.

Set latitude (3): Used to set initial and corrected positions manually.

Set longitude (4): Used to set initial and corrected positions manually.

Set trace (5): Used to position the bug manually in the tracing compartment before beginning a plot. The cross screw moves the bug front to back or back to front; the lead screw permits moves the bug left to right or right to left.

Chart orientation (6): Selects desired orientation for chart alignment by switching the coordinate functions of the lead screw and the cross screw.

Trace timer (7): OFF/ON control for the pencil assembly solenoid actuating circuit, which is controlled by the clock. See figure 9-6.

Projection lamp OFF/ON (8): Provides power to the projection lamp (bug).

Trace motors (9): Provides power to the lead screw and the cross screw.

Slew rate FAST/SLOW (10): Used to select fast or slow slewing rate for the bug.

Operation (11): Used to select either normal operating or test signals for longitude and latitude coordinate inputs to the DRT. The NORMAL position selects normal operating input signals from DRAI. The OFF position has no inputs from any source.

Scale (12): Used to select either normal operation or 200-yards-to-the-inch emergency operation.

Chart scale nautical miles/inch (13): Used to set the DRT scale to the desired tracking scale, variable from 0.1 to 99.99 nautical miles per inch.

Longitude (14): Indicates ship's present longitude.

Latitude (15): Indicates ship's present latitude.

Q1. What piece of the dead reckoning system receives inputs of own ship's speed from the underwater log (pitometer log) and own ship's course from the master gyrocompass?

Q2. What is the purpose of the dummy log?

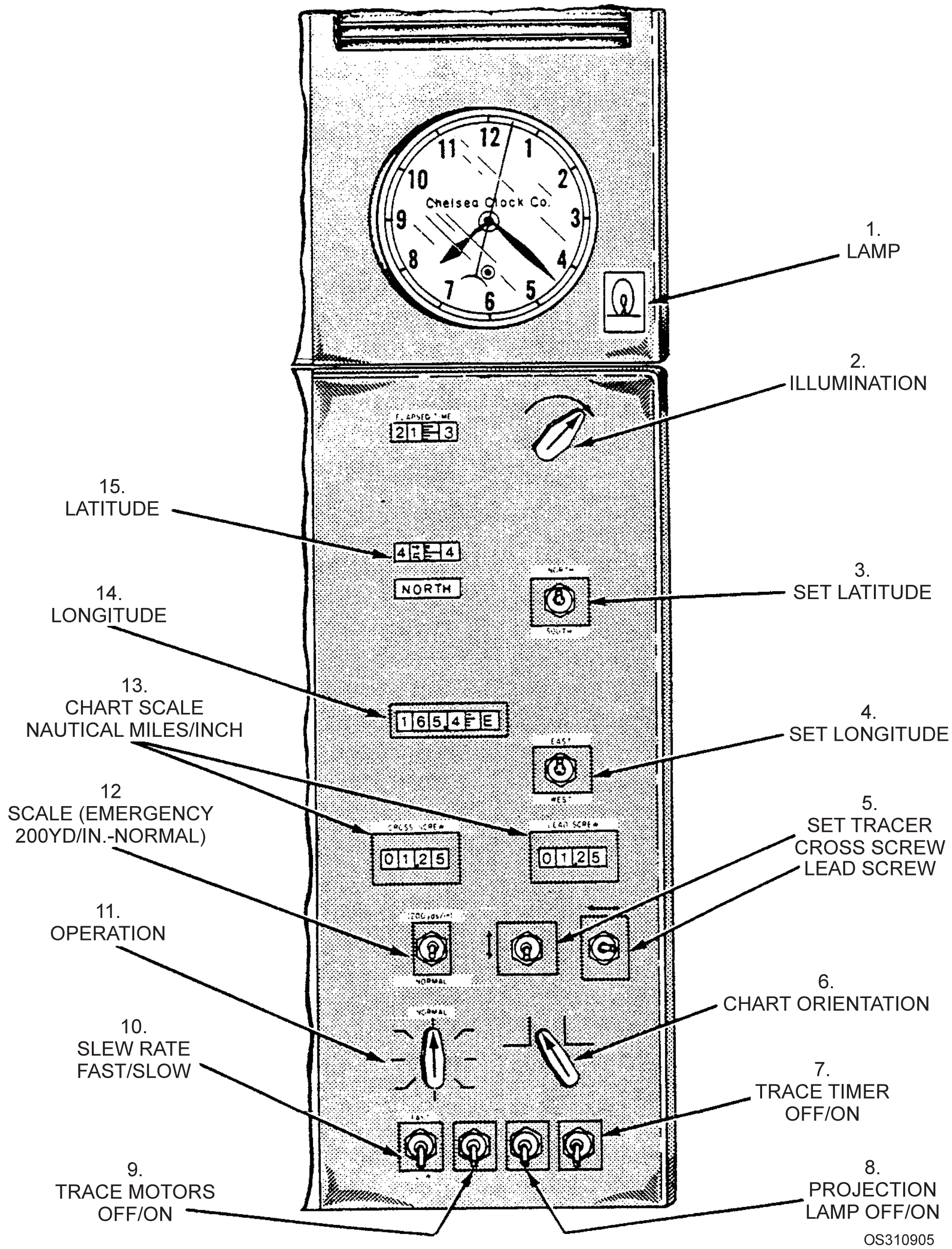

Figure 9-5.—DRT operating controls.

DRT OPERATION

If you are assigned to operate the DRT, follow the procedures listed below to prepare the DRT for use and to secure it.

1. Ensure that the plotting surface glass is clean on both sides. Place tracing paper on the tracking surface and secure its corners with tape. Draw any diagrams or reference lines required.
2. Position the bug at the desired starting point; use the set tracer switches to slew the bug. Arrows next to the switches indicate the direction of drive. Slew may be fast or slow; use “slow” for fine positioning.
3. Set the “chart orientation” switch to the desired position. North normally is at the top of the tracer.
4. Set in own ship’s present latitude position by pressing the “set latitude” switch in the proper direction.
5. Set in own ship’s present longitude by pressing the “set longitude” switch in the proper direction.

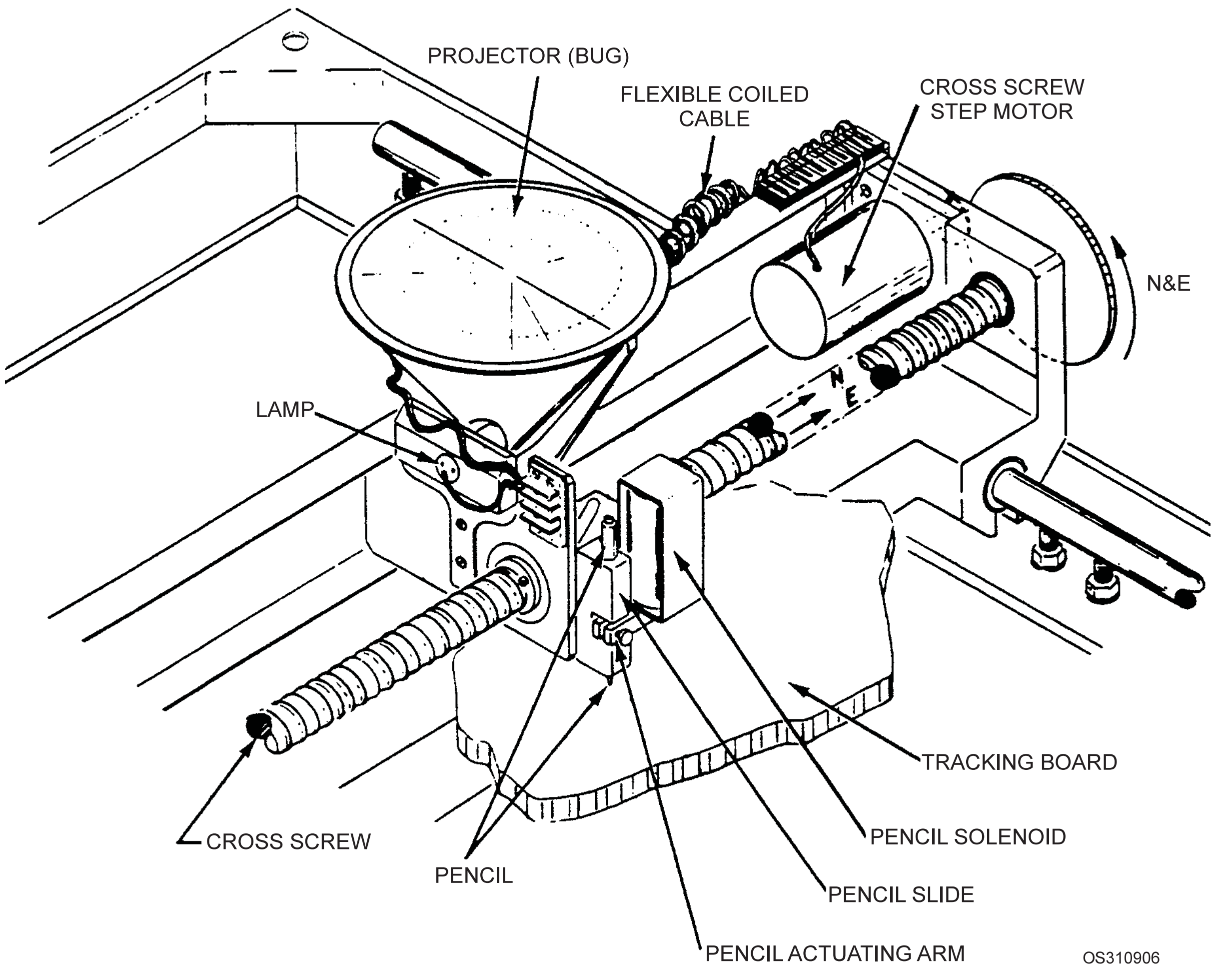

Figure 9-6.—Pencil and projector assemblies.

6. Set the tracking scale by positioning the cross-screw and lead-screw digital switches to read directly the scale you desire for tracking. In emergencies, such as man overboard, you may position the "scale" switch to EMERGENCY, which sets the scale to 200 yards per inch.
7. Adjust the illumination desired.
8. Secure the DRT by turning the "operation" switch to the OFF position. If the DRT is to be secured for an indefinite period of time, it should also be secured at the IC switchboard.

NOTE

The DRT should never be left with the operation switch in any of the test positions except when actual tests are being made.

PARALLEL MOTION PROTRACTOR

Plotting course lines requires the use of some type of straightedge. On the DRT, the straightedge is part of the Parallel Motion Protractor (PMP) (fig.9-7). The PMP is a device that allows a straightedge, positioned in any desired direction, to be moved anywhere on the plotting surface, at all times maintaining the same direction. One end of the PMP is fastened rigidly to the framework of the DRT. The other end of the

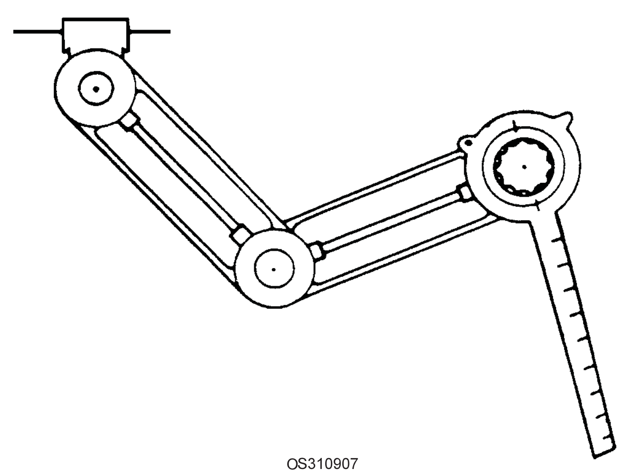

Figure 9-7.—Parallel motion protractor (PMP).

two-section pivoted arm has a bearing circle. A circular plate with four index marks spaced 90° apart, to which a plastic range ruler is attached, rotates within the bearing circle, thus providing the means for measuring exact directions and ranges. Figure 9-7 illustrates a parallel motion protractor with ruler attached.

Alignment Procedure

In normal use, the bearing circle is aligned with the DRT bug, locked, and then not disturbed until there is evidence of slippage or the ruler needs to be realigned. To align the DRT, turn on the light in the bug and turn off the drive motors. Mark the position of the bug, then move the bug manually a foot or more in one of the four cardinal directions and mark its position again. Use these two marks to line up the plastic ruler. Then lock the bearing circle so that the cardinal headings match the four indices.

Locking Range Rule

When you have aligned the protractor properly, it is ready for use. Two methods are permissible for holding the range rule on a desired bearing. In one method, you may move the PMP to the preferred position after adjusting the range rule to the proper setting and locking the rule lock firmly.

In the other method, you may hold the bearing circle and the index circle tightly with your thumb and forefinger while sliding it across the plot. This method is faster and, therefore, generally preferable to the method described above. However, you must be careful to not let the bearing circle slip. Slightly different models of the PMP are in use; some models have controls and locks not available on others. The locks described in this chapter are common to all models.

DRT CASUALTIES

Like any other mechanical and electrical device, the DRT is not infallible. Always be prepared for a casualty. Should a casualty occur, inform your supervisor immediately because the assistance of an Interior Communications Electrician may be required. Immediately extend your present course line from the last position plot. For example, should own ship be on course 260° when the DRT fails, set this course on the PMP arm, and draw a light line in this direction from the last position of the ship's DR track. A light line does not interfere with the remainder of the plot when the ship changes course. Dead reckon own ship's position along this line.

To determine the distance the ship travels each minute, apply the 3-minute rule, based on own ship's speed. From this new dead-reckoned course, continue the plot on all contacts.

Place the time along the track only when the ship *should* reach that point. In this manner, the ship's location is always indicated. Do not DR more than a few minutes ahead, because there is a possibility that the ship may change course and speed. Draw the DR line lightly so that if the ship changes course, you will be able to overlook the unneeded portion of the line, thus avoiding confusion while keeping the plot neat and clean.

A casualty to the ship's gyro presents a serious problem. If the gyro fails, movement of the bug becomes unpredictable. In some ships, such a casualty can be corrected either by shifting to another gyro or by shifting to "manual" and manually inputting courses into the DRAI. In some ships, the Own Ship's Motion Simulator (OSMOS) can be used for course inputs.

Blacking out of the bug light is another casualty the DRT could suffer. Although a simple casualty, it can make tracking as impossible as a major DRT failure. Always keep a supply of spare bulbs on hand.

Conversion of Bearings

If the gyro fails, you must use relative bearings and convert them to true bearings in order to continue the plot. You can simplify the conversion by using the following formula:

"True course (corrected true course if magnetic or compass headings are used) plus relative bearing equals true bearing." The following are some examples of the conversion of bearings.

True course	Relative bearing	True bearing
135	080	215
075	035	110
245	200	085

Notice in the last line of the above example that 245° added to 200° equals 445°, which of course is greater than 360°. Subtract 360 from 445 (because a circle contains only 360°); 445 minus 360 equals 085, which is the true bearing. In every instance where the

sum of the true course and the relative bearing exceeds 360, subtract 360 from the sum to obtain the true bearing.

NOTE

To convert true bearings to relative bearings, use the following formula: "True bearing minus true course equals relative bearing." Set the PMP bearing dial on the ship's course; relative bearings are automatically converted to true bearings.

Halifax Plot

Dead reckoning during a DRT casualty is a relatively simple procedure when own ship is steaming on one course at a constant speed. However, if own ship is maneuvering, dead reckoning is not reliable, and you must use a Halifax plot.

The Halifax plot (fig. 9-8) is a homemade plotting board. It is usually made from a maneuvering board and constructed with cardboard backing for rigidity. You should draw your ship's turning circle for various predetermined speeds on the plot or have several plots already made up, one for each speed.

Three Operations Specialists are required whenever the Halifax plot is used. One OS (the regular DRT operator) continues to mark own ship (the center of the plot) and all surface contacts designated. Another OS positions the plot, under the DRT paper, and moves it according to the ship's movement. By the use of dead reckoning and the 3-minute-rule principles, the plot is moved from one position to the next. The third OS calls out the "mark" at 30-second intervals and gives the ship's course and speed. Because of maintaining a plot through numerous course and speed changes, it is recommended that the ship come to a steady speed before the plot is used.

The person manipulating the plot must have a working knowledge of the ship's tactical and maneuvering characteristics.

Using the plot properly requires practice. Each watch section should practice with a team until it achieves proficiency.

Q3. What is the proper procedure for aligning the ruler on the PMP arm?

Q4. What is the proper casualty procedure to use if the DRT fails while your ship is conducting maneuvers?

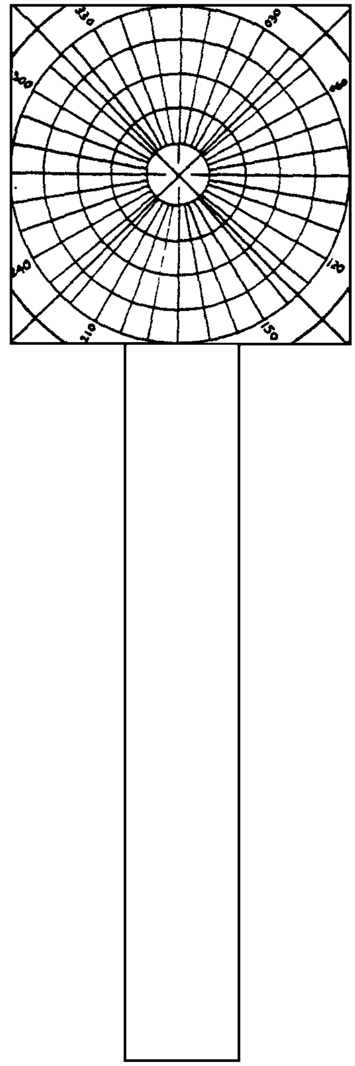

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Figure 9-8.—Halifax plot.

GEOGRAPHIC PLOT

As we mentioned earlier, the DRT is capable of producing a graphic record (dead-reckoning track) of the ship's path. Tracking can be done automatically, by means of the pencil carried across a paper fastened to the table surface immediately below the bug. However, the automatic method is rarely used because of the inaccessibility of the plot for making additional or explanatory notations. Normally an operator will mark the center of the bug on tracing paper (DRT paper) fastened on top of the glass-plotting surface. In rare cases, you may wish to use both plotting methods simultaneously and later superimpose one plot over another.

Although the DRT was developed as a navigational tool, it is useful in the field of operations. You can make a geographic plot directly on a chart to show the

ship's path in and out of a harbor or around islands. When you prepare to do so, you must set the DRT mechanism to the chart scale. Remember, a chart scale usually is expressed as a ratio. For example, l/20,000 means that 1 inch on the chart corresponds to 20,000 inches on the Earth's surface. You can convert this figure to yards per inch by dividing by 36 or to miles per inch by dividing by 72,000.

The chief value of the DRT is its use in analyzing ship movements. It is also useful in planning and carrying out ship maneuvers. As a geographic plotting device, the DRT uses TRUE courses and speeds. Marking the bug indicates your ship's true position in relation to the topography and other ships in the area in which you are operating. Connecting these plotted positions yields the ship's true track. Plotting ranges and bearings of the contacts, using own ship's position as references, establishes their true positions. Tracks are established by connecting these positions (plots). An experienced DRT operator can maintain up to six contact plots simultaneously while supplying essential data on contacts plotted. The principal navigational function of the DRT, regardless of the position of the bug or alterations to the scale, is carried out by the latitude and longitude dials.

The record provided by the DRT of an action during wartime may be an invaluable aid in conducting a surface engagement or in reconstructing the situation later. In peacetime, a DRT plot may be equally important in evaluating exercises, groundings, or collisions. In grounding and collision situations, the DRT tracings become a legal record. Therefore, they must be kept neatly and accurately. No erasures may be made on the plot. Erroneous information or mistakes must be canceled by drawing a single line through that portion of the plot. The DRT tracings must be stored on board for a period of 6 months, then destroyed, unless otherwise directed. DRT tracings should contain a legend, usually in the lower-right corner, that includes, but is not limited to, the following information: north-south reference line, name of the ship, scale used, date, time the trace was started, ship's position (Lat-Long) at the start of the trace, wind direction, sea state, grid origin, name of plotter(s), type of operation (ASW, AW, SUW, NSFS, etc.), and assisting ships.

When the DRT is used for tracking contacts, the 2000-yards-per-inch scale is the most popular. The 36-inch-square plotting area of the DRT then becomes a 36-mile square. Should a more detailed plot be desired, you may increase the scale as desired. Usually, the 200-yards-per-inch scale is used for man overboard. When a printed chart with its preprinted scales is not used, some other means must be used to enable the operator to measure and plot distances. The most common substitute is the plastic ruler, which attaches to the parallel motion protractor (PMP). Figure 9-9 shows two plastic rulers. One has scales of 2000- and 500-yards-per-inch; the other has scales of 1000- and 200-yards-per-inch. (You may draw a scale along the edge of the tracing paper and then transfer distances with a pair of dividers. You may also draw a scale on a strip of masking tape and fasten the tape to a plastic ruler for use with the DRT.)

In the center of the ruler are speed scales calibrated for various times.

DEVELOPING OWN SHIP'S TRACK

The moving bug indicates the position of own ship at all times. Suppose the ship is steaming on course 090° at 15 knots. Place a pencil mark in the center of the bug at time 1500 and again 3 minutes later. By then the bug would have traveled 1,500 yards in a direction of 090°. To measure distance traveled, lay the PMP ruler in a line from dot to dot in the direction of bug movement. Read the distance, in yards traveled,

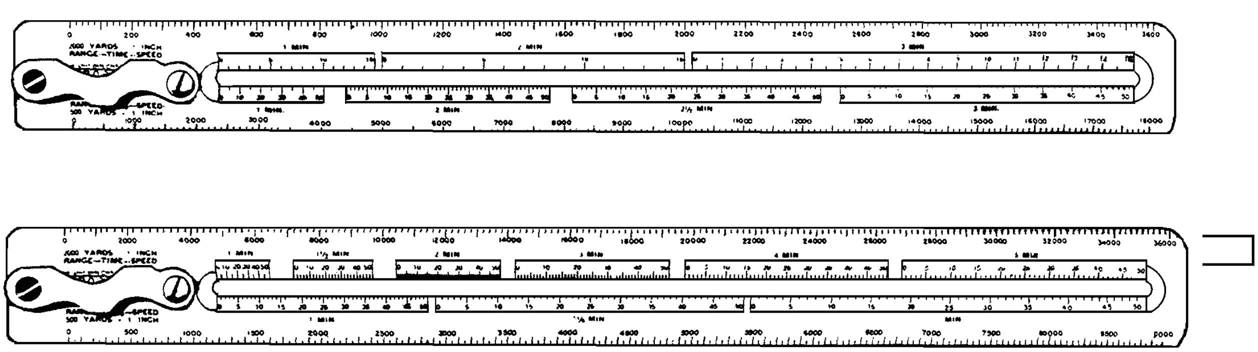

Figure 9-9.—PMP range scales.

directly off the scale. Read the ship's course from the PMP bearing indicator. Develop own ship's track by marking a small dot over the light. When you start a track, record latitude and longitude in the legend (indicated on the latitude and longitude dials).

Indicate time of the mark next to own ship's track. On the first plot show the hour and minute in a four-digit number. For succeeding positions on the same track, use only two-digit numbers, indicating minutes, until the next hour. At the next hour, again record the four digits to show the hour to which the minutes refer. Occasionally, you may need to show quarter-minute time exponents next to the track.

PLOTTING BEARINGS AND RANGES WITH PMP

Two methods of plotting ranges and bearings help eliminate awkward movements of the protractor: direct and indirect. Use the one most convenient for the contact you are plotting. These plotting methods vary according to the contact's range and bearing and the position of the bug in relation to the contact.

Direct Plotting

Figure 9-10 illustrates the direct plotting method. It is summarized as follows:

1. Plot own ship's position at the time the range and bearing are taken.
2. With the range ruler free to rotate, set the bearing indication arrow (that points toward the ruler) on the desired bearing, then lock the PMP. Do not lock it too tightly. Doing so may throw it out of alignment.
3. Place the zero mark on the ruler exactly on own ship's position so that the edge of the ruler extends along the true bearing line from own ship's position.
4. After you hear the range, repeat it mentally while you place the protractor in position. Now read outward from zero to the contact's reported range and mark the point.
5. Immediately after you establish the range, release the rule lock on the PMP, making it ready for use. At the plot of the contact, record the same time that you recorded next to own ship's position that served as a reference point.
6. Move the PMP clear of the plot so the evaluator has an unobstructed view and so you can "dress up" the plot.

Indirect Plotting

An example of indirect plotting is illustrated in figure 9-11. Indirect plotting makes use of the reciprocal bearing mark on the PMP. By the use of this method, you can easily plot most targets that are awkward to handle by direct plotting. The basic steps of indirect plotting are listed below:

1. Read the desired bearing beside the arrow that is 180° from the ruler side of the PMP arm.
2. Place the desired range, instead of the zero mark, at the marked position on own ship's track.
3. Plot the target's position at the zero mark on the ruler.

Many times the DRT operator is required to track several contacts. When you are tracking five contacts and plotting only one each minute, the plots of each contact will be 5 minutes apart. Usually this period of time between plots is too great, especially at close

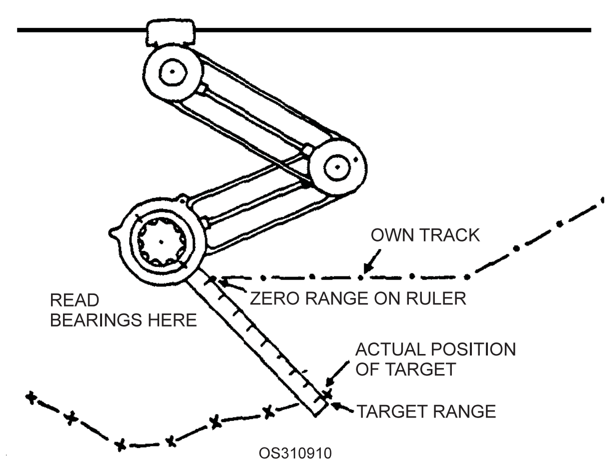

Figure 9-10.—Direct plotting method.

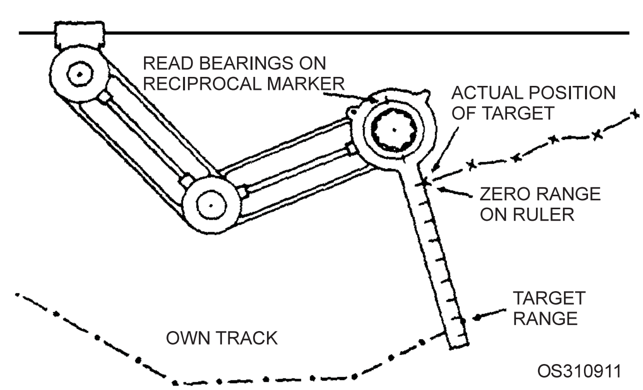

Figure 9-11.—Indirect plotting method.

ranges. An Operations Specialist Third Class should be able to maintain a track of a least three contacts a minute on the DRT. This requirement means that the radar operator will be sending ranges and bearings frequently over the phones. At such times, you must remember many numbers while also determining each contact's course and speed. For a memory aid, most ships have a surface status board.

The person manning this position—called the surface recorder—is usually an alternate operator and is on the same sound-powered phone circuit as the radar operator and plotters. He or she records each range and bearing as it comes over the circuit from the radar operator, together with the time of each report. This record keeps the evaluator informed and serves as a backstop to plotters. If plotters miss the range, bearing, or time of a report, they can refer to the recorder board. As soon as a plotter obtains and disseminates a course and speed solution, as well as the point and time of closest approach of the target, the recorder enters the information on the status board.

When the standby-mark method of plotting is used, the recorder acts as a timer for both the radar operator and plotter. In this instance, he or she watches the clock and calls "Stand by (contact designation)." This expression warns the radar operator to have a bearing and range ready and alerts the plotter to stand by to mark the bug's position on the DRT. On hearing "Mark" from the recorder 10 seconds later, the plotter marks the bug while the operator sends range and bearing information to the plotter. On receiving the range and bearing, the plotter plots the contacts. This method is used when several surface targets are tracked at the same time. Also, it is used for tracking submarines on the DRT when ranges and bearings from the sonar gear are used.

DETERMINING TARGET COURSE

Earlier, we explained how to compute own ship's course by laying the PMP ruler along pencil dots that resulted from marking the bug. You determine a target's course in the same manner. Align the PMP ruler along the target's plots and read the indicator on the PMP in the same direction as the target is moving. A word of caution: plots do not always fall in a smooth track. Although the plotter can cause erratic plotting, the same result can be caused by a radar operator giving ranges and bearings that are slightly erroneous. Figure 9-12 illustrates the correct procedure in such a situation. Lay the PMP ruler along the mean of the plots and read the indicator. If the contact's plots

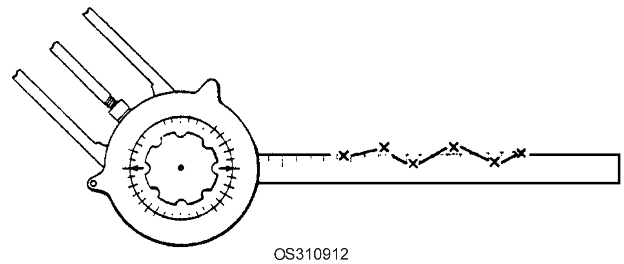

Figure 9-12.—Example of how course is determined.

moved from right to left, the course to read is indicated on the left side of the PMP.

DETERMINING TARGET SPEED

There are several ways to determine speed. One is the "basic formula". Another, of primary importance to you, is the 3-minute rule.

Basic Formula for Determining Speed

You can determine speed by using the basic formula:

$$\text{Speed} = \text{distance}/\text{time}.$$

When you divide distance traveled (in yards) by time (in minutes), you will obtain speed, (expressed in yards per minute). To convert this result to nautical miles per hour (knots), first multiply by 60 minutes (which gives yards per hour), then divide by 2,000.

Assume that a target travels 1,100 yards in 3 minutes. When you apply the basic formula, you will find the speed of the target to be 11 knots.

Although the basic formula will provide you a speed based on distance and time, using it is not nearly as fast nor as satisfactory as using the 3-minute rule. The 3-minute rule is used on the maneuvering board, surface plot, and DRT. It is also used in air plotting, except that the scale is in miles, instead of yards.

3-Minute Rule

The 3-minute rule, simply stated, is: To find a contact's speed, find the number of yards the contact traveled in 3 minutes and point off, or drop, two numbers from the right side of this figure and change "yards" to "knots". For example, if the contact traveled 1,700 yards in 3 minutes, its speed is 17 knots.

As another example, assume that a contact travels 800 yards in 2 minutes. This target would travel 400 yards in the next minute, making a total of 1,200 yards

in 3 minutes. Therefore, its speed must be 12 knots. By the same kind of mental arithmetic, you can use the 3-minute rule to convert 1 minute, 1-1/2 minutes, and other times of travel. Thus, if a target covers 800 yards in 1-1/2 minutes, it would travel 1,600 yards in 3 minutes, and its speed is 16 knots. If it traveled 1,100 yards in 1 minute, it would cover 3,300 yards in 3 minutes and must be making 33 knots.

When the required range scale is available, there is an easy method for determining both target course and speed at the same time. Down the center of each range ruler are speed scales calibrated for various time periods (fig. 9-9). To determine speed, select the amount of track time desired and align the appropriate time-speed scale with it; e.g. for 2 minutes of track, use the 2-minute speed scale. At the same time, you may determine the target's course from the PMP bearing dial.

CONTACT DESIGNATION

Surface contacts may be internally designated by letter, assigned in sequence, beginning at 0000 local time. They are referred to by the code words *Skunk* or *Friendly*, as appropriate; for example, Skunk A, Friendly B, and so on. If all the alphabet is used, subsequent contacts are assigned two letters, such as AA, AB, and AC. When a contact is designated, it is identified on the plot by placing the letter designator in a large circle (the size of a quarter) near the origin of the contact's series of plots.

If a surface track splits into two or more parts, each part is assigned a secondary numeral after the primary letter designator. Secondary numeral designators are assigned in order clockwise from true north at the point at which the split occurs; for example, Skunk Al and Skunk A2. The primary letter designator and the secondary numeral designator are placed in a circle near the point of the split. If two parts of the contact are on the same line of bearing, the part nearest the ship is assigned the smaller designator number. Parts of a split may also be redesignated. For example, Skunk A that splits may be redesignated Skunk D and Skunk F. We will discuss external contact designation in a later chapter.

DATA RECORDED ON PLOTS

Each plot provides a graphic, step-by-step account of events by means of symbols and abbreviations in boxes alongside own track and the target track. The picture it presents depends solely on the ability and skill of the plotter. Figure 9-13 illustrates the proper technique of recording data.

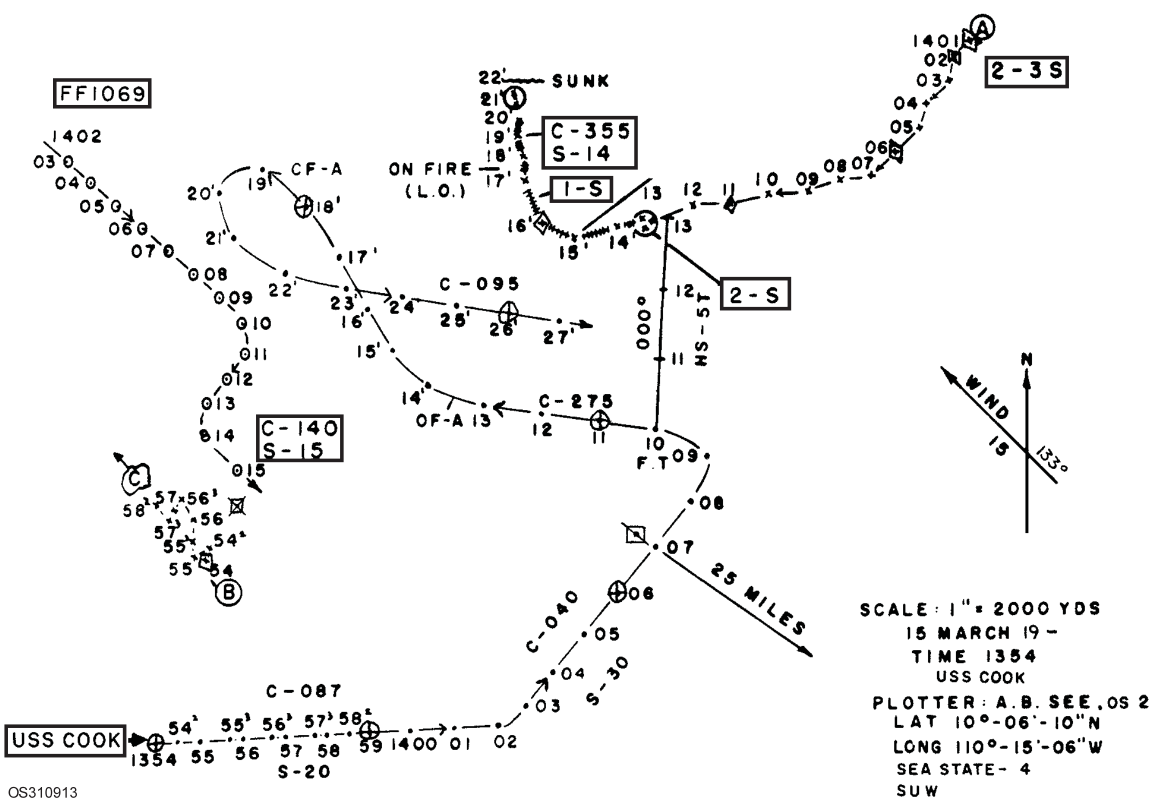

Figure 9-13.—Example of a DRT plot (recording data).

Alongside own ship's track, indicate information such as point of opening fire, point of firing torpedoes and number fired (ASW), with corresponding arrows, base course and speed, point where own ship received shell or torpedo hits, any action performed by own ship or that happens to own ship during the track, and changes in course and speed.

Next to the target's track, indicate its composition by number and type, or the best estimate available. Before number and type are established, the best information usually approximates the number (as one, few, or many); types are classified as large or small. Always box the composition of the contact. Circle the target designation letter at the beginning of the track. Whenever the target's course and speed are determined, placed them in a box at the appropriate track time.

Include amplifying data along the enemy track, such as "slowing", "on fire", or anything that happens to the target. Record the source of information (other than radar or sonar) near the track.

Indicate the mode of IFF shown by a friendly contact beside the track at the point where the operator reports it. Make the symbols a prominent size but do not enclosed them in a box.

Where appropriate, include the following additional data on the plot: reference points, such as Point Romeo, Point Oscar; position of intended movement; and geographic points.

MAN OVERBOARD PROCEDURE

All Operations Specialists must know what to do when someone is reported overboard. Having this knowledge helps the crew consume minimum time in recovering the individual(s). Because of varying factors aboard ship, each ship has its own man overboard procedure. Operations Specialists must, therefore, read the CIC doctrine to ensure that they fully understand all of their man overboard responsibilities.

A DRT plotter is indispensable in a man overboard situation. Although plotting procedures vary, the basic functions a plotter *must* perform are as follows:

1. When a man overboard report is received, a plotter must quickly mark the bug, indicating ship's present position, and change the DRT scale to 200-yards-to-the-inch. (When the bug is near the edge of the plotting surface, the plotter must reposition it to approximately the center of the plotting area.)
2. The ship's position at the point where the individual actually went over the side must be determined. Since a lapse occurs between the time of the incident and receipt of a report in CIC, a correction is required in the initially indicated position. One correction procedure you can use is to locate the person at a point on the reciprocal of the ship's course, at a distance of 100 yards for each 5 knots of speed. Then plot the offset from the initial point and labeled it.
3. Finally, determine the bearing and range to the person every 15 to 30 seconds. Keep sending this information to the conning station and lookouts until the person is sighted.

Q5. What is the purpose of the 3-minute rule? How do you use it?

Q6. When a man overboard is reported, to what scale should the DRT be set?

ANSWERS TO CHAPTER QUESTIONS

A1. The Dead Reckoning Analyzer Indicator (DRAI).

A2. The dummy log serves two purposes: (1) to simulate ship's movement through the water (for training personnel and aligning equipment) and (2) to serve as a backup for the underwater log system.

A3. To align the DRT, turn on the light in the bug and turn off the drive motors. Mark the position of the bug, then move the bug manually a foot or more in one of the four cardinal directions and mark its position again. Use these two marks to line up the plastic ruler. Then lock the bearing circle so that the cardinal headings match the four indices.

A4. Use a Halifax plot.

A5. To find a contact's speed. Find the number of yards the contact traveled in 3 minutes and point off, or drop, two numbers from the right side of this figure and change "yards" to "knots". For example, if the contact traveled 1,000 yards in 3 minutes, its speed is 10 knots.

A6. 200 yards per inch.

CHAPTER 10

PLOTTING

LEARNING OBJECTIVES

After you finish this chapter , you should be able to do the following:

1. Discuss basic plotting definitions and plotting terminology.
2. Discuss the various types of surface plots and the associated reports sent to the bridge.
3. Discuss the various types of air plots.
4. Discuss the procedures for ASW plotting and how to use the Halifax plot under emergency conditions.
5. Discuss the contact information reports sent to the bridge.

INTRODUCTION

One of the most important functions of CIC is to display information. To perform this function, CIC receives and processes raw information into useable forms. Figure 10-1 shows an example of how information flows to, from, and within a typical CIC. To perform their duties effectively, key personnel such as the evaluator/TAO, CIC officer, and CIC watch officer and air controllers and command personnel depend on Operations Specialists to keep the information accurate, up-to-date, and in an easy-to-read form. This means that to perform your job properly, you must learn the techniques, symbols and abbreviations, equipment, and types of displays used in CIC well enough to produce the desired display accuracy for every situation.

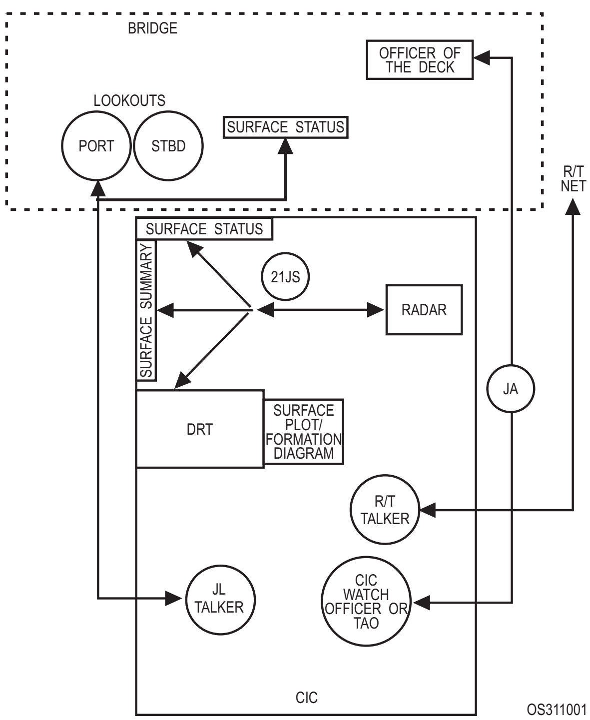

Figure 10-1.—Example of the flow of information within CIC.

In chapter 2, we discussed the various plots and status boards used to display both tactical and strategic information. Recall that plots provide a visual reference of the positions of friendly and enemy units and forces. Some plots are static in nature; others show movement. Some plots cover large areas and show both friendly and enemy forces; others depict only own units within a small area. Many of the displays used in CIC today are automated or are maintained and displayed in some type of electronic format. Still, basic plot characteristics, plotting procedures, and plotting abbreviations and symbols remain the same.

We discussed geographic (DRT/DDRT) plots in chapter 9. In this chapter, we will deal primarily with the surface and air summary plots (and related status boards) and the procedures for ASW (anti-submarine warfare) and TMA (target motion analysis) that present a relative picture of the surface and air situation around own ship.

BASIC PLOTTING DEFINITIONS AND TERMINOLOGY

To develop and maintain plots properly, Operations Specialists must be thoroughly familiar with basic bearing terminology. Suppose CIC receives the following request from the captain: "What course will take me to a position 2,000 yards west of the contact, and how long will it take to get there at a speed of 30 knots?" The surface plotter must solve this problem and give the captain the correct answers, quickly and accurately. There is no excuse for an incorrect solution. When the captain requests a course to a certain position, he must have the information in a matter of seconds—not minutes. You may use various methods to solve such a problem (the DRT/DDRT, the surface plot, or the face of the scope), but you will normally use the surface plot or a separate maneuvering board.

In the example above, the captain might have requested the information in the following manner: "I want a course to take our ship to a position 2,000 yards from the target at a target angle of 300°. We will use a speed of 30 knots to make the maneuver."

Or he might have said: "I want a course to take our ship to a position 2,000 yards bearing 270° true from the contact."

The three bearings the captain requested were *true bearings*. But he could just as easily have asked for *relative bearings*. Therefore, you must know the exact meaning of both true and relative bearings and must also have a thorough understanding of how to convert true bearings to relative bearings, and vice versa. In this section, we will discuss both types of bearings and how to determine them.

BEARINGS

A *bearing* is simply a direction to a target (or object). The principal bearings used in CIC are *true* and *relative*. Each type serves a useful purpose at one time or another. Other types of bearings are *reciprocal* and *target angle*. Figure 10-2 illustrates all of these types of bearings. All bearings are measured clockwise from their reference point.

Line of bearing: The line connecting the positions of two objects.

True bearing: The angular measurement between true north and the line of bearing to the object. Unless stated otherwise, all bearings used in CIC are true.

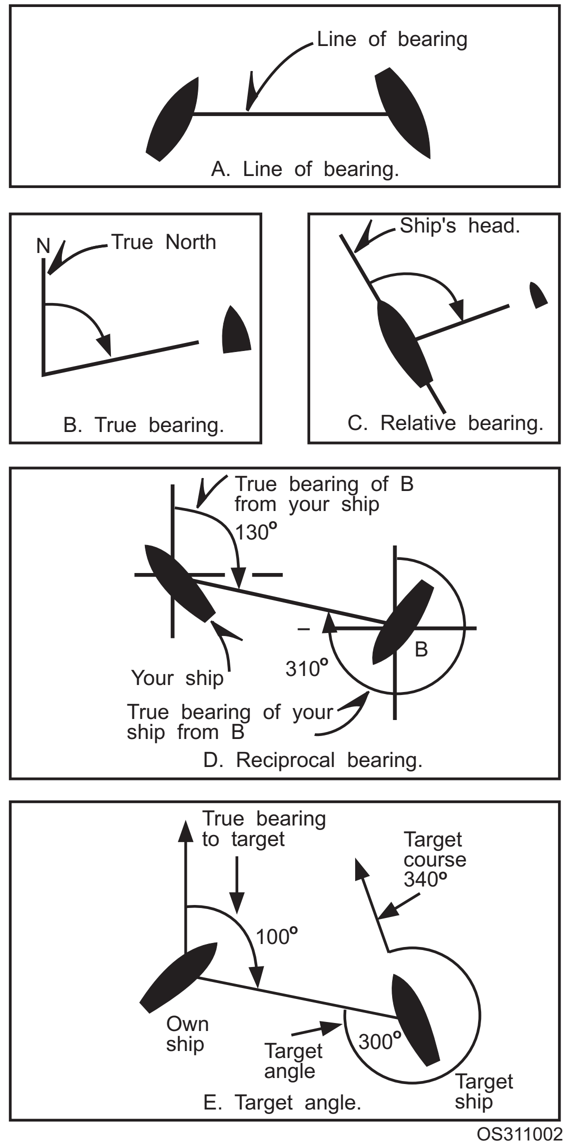

Figure 10-2.—Types of bearings.

Relative bearing: The angular measurement between own ship's head (own course) and the line of bearing to the object.

Reciprocal bearing: A bearing that is 180°, plus or minus, from any given bearing. Look at view D of figure10-2. Ship B bears 130° true from own ship. The reciprocal of 130° is 310°. Therefore, own ship bears 310° **from** ship B.

Target angle: The relative bearing of own ship from a target ship. It is the angular measurement from the target's head clockwise to the relative bearing of own ship.

By using the following formulas, you can determine a true or relative bearing arithmetically by using a given bearing and own ship's head.

1. The true bearing of an object equals the object's relative bearing plus ship's head (TB = RB + SH). When the answer exceeds 360°, subtract 360°.
2. The relative bearing of an object equals the object's true bearing minus ship's head (RB = TB - SH). When SH exceeds TB, add 360°to TB before you subtract SH.

To determine the target angle, use the following formula:

> Target angle equals the true bearing of the target from own ship, plus or minus 180°, minus the course of the target (TA = TB ± 180° -TCO). For example, assume that the true bearing of a target on a course of 340° is 100°. Add this bearing to 180°. Now subtract the target's course (340°). Because you cannot subtract 340° from 280°, add 360° to the target's true bearing before you subtract the target's course. The target angle is 300°.

RELATIVE PLOT

Relative movement is the movement of one object in relation to another—the movement that takes place between two objects when one or both are moving independently. Likewise, the distance moved and the speed of the movement are relative values.

A *relative plot* is a drawing to scale showing the position of one moving object relative to other objects. Special plotting sheets, called *maneuvering boards*, are printed with polar coordinates for plotting bearings, and with concentric circles for plotting distances.

In CIC, relative plots are maintained on maneuvering boards and on vertical plotting boards called *summary plots*. (Maneuvering board plotting is discussed in chapter 11.)

Q1. What is a reciprocal bearing?

Q2. What is a target angle?

SURFACE PLOTTING

During the course of a watch, an Operations Specialist may be rotated at 30- to 60-minute intervals between such positions as surface search radar operator, DRT plotter, surface plotter, S/P telephone and radiotelephone operator, surface summary plotter, tote board keeper, and surface status board keeper.

In the next few sections, we will discuss some of the plots and status boards of primary importance to the surface picture, and the information found on them. We will not attempt to prescribe physical requirements for the format of the plots and status boards, since their layout, size, and location are greatly influenced by the mission of the ship, available space, CIC doctrine, and the arrangement of equipment in CICs.

We introduced the primary surface plots and status boards in earlier chapters. In this chapter, we will discuss their functions in connection with plotting and will point out how each status board works in conjunction with a plot to develop a complete picture. The following plots pertain to the surface picture:

1. Geographic plot
2. Surface plot
3. Formation diagram
4. Surface status board
5. Strategic plot
6. Nuclear detonation

GEOGRAPHIC PLOT

The geographic plot (also called the navigation plot) shows the true movement of surface, subsurface, and certain air contacts. The geographic plot is maintained on the dead-reckoning tracer (DRT) (refer to chapter 9).

The geographic plot consists of a piece of tracing paper over the DRT. When the ship is engaged in shore bombardment or radar piloting in restricted waters, a chart of the area is put on the DRT in place of the tracing paper. A neat and complete track of all contacts should be kept on the geographic plot. The plot can serve as a vital log and should be treated as such for all events requiring a navigational track.

SURFACE PLOT

The surface plot is one of the most important plots maintained in CIC. When properly kept, the surface plot eliminates confusion by providing continuous identification of other vessels.

The surface plot is a comprehensive, relative display of the positions and tracks of friendly, enemy, and unidentified surface and subsurface targets, of geographical points, and of other data required for an understanding of the complete surface picture.

The surface plot is kept in polar coordinates (true ranges and bearings), usually on a maneuvering board. If space permits, a 36-inch edge-lighted vertical plotting board scribed in the same manner as a maneuvering board also is used. The latter is called the *surface summary plot*. Both plots show essentially the same information, with the summary plot being visible to more people. Also, because of its size, the summary plot is less cluttered, making situations easier to evaluate. In our discussion the term *surface plot* applies to both plots, with differences noted as necessary.

When a surface summary plot is kept, the maneuvering board is used mainly for determining a contact's course, speed, and closest point of approach (CPA).

Plotting Symbols and Abbreviations

All surface and air plots use standard symbols and abbreviations to provide the most information without unduly cluttering the plot. Although most information comes from radars, there are other sources that must be identified. For example, "LO" alongside a plot indicates a lookout report; "COM" means a radio report.

Formation symbols are shown in figure 10-3. They are used on all plots to indicate at a glance the positions of various types of units.

Plotting symbols are shown in figure 10-4. Table 10-1 lists plotting abbreviations. Some of the symbols and abbreviations are used only on the geographic plot, some only on the surface plot, and some on the air plot, while some are used on all plots. Whatever your plotting assignment, you must know all the symbols and abbreviations and when and where to use them.

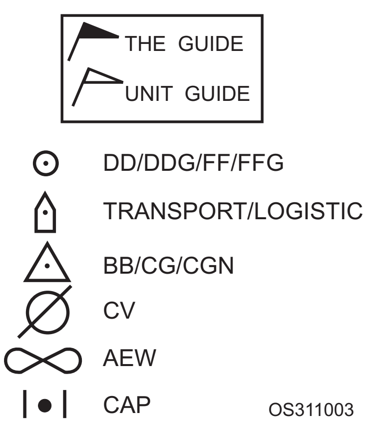

Figure 10-3.—Example of formation symbols.

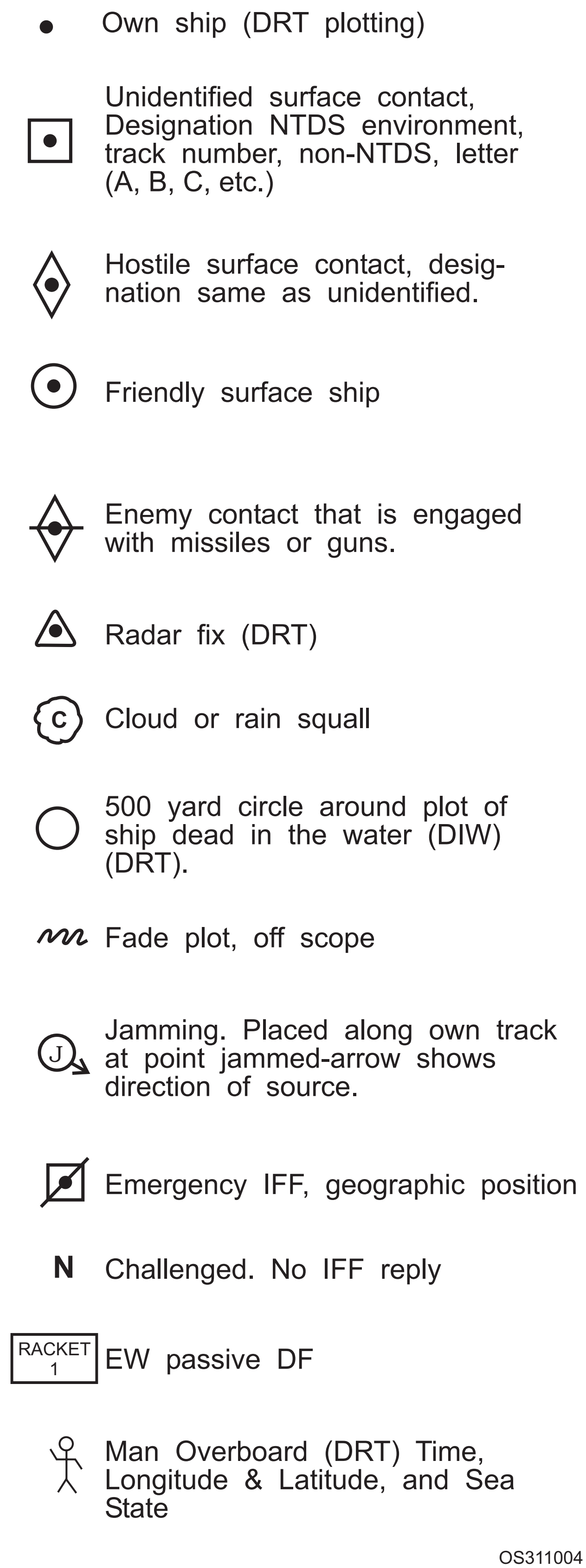

Figure 10-4.—Example of surface plotting symbols.

Table 10-1.—Surface Plotting Abbreviations

L	Large Ship (prefaced by number)
AEW	Airborne Early Warning
S	Small Ship (prefaced by number)
LAT	Latitude
LONG	Longitude
C	Course
S	Speed
C/C	Changed Course
C/S	Changed Speed
DK	Radar Decoy
OF	Opened Fire
CF	Ceased or Checked Fire (add letter to indicate target)
LO	Lookout Report
COM	Radio Report
SON	Sonar Report
PIN	Assumed Friendly Emission
VOL	Enemy Guided Missile Signal
RAK	Intercepted Electronic Transmission
MOB	Man Overboard
MS	Make Smoke

Plotting Procedures

We will now discuss how to develop a surface plot. Our discussion assumes that own ship is part of an AW formation. Figure 10-5 illustrates how the surface summary plot is kept.

On a surface plot, your ship is always in the center. When setting up the plot, always indicate formation type, center, guide, axis, course, and speed. Show the wind force and direction at the outer edge of the plot.

Plot the major units of the formation in relation to own ship, together with their identities, such as station designations or call signs. (You can get bearings and ranges of other ships from the formation diagram, which we will discuss later.) All formation units, their stations, and their call signs are listed on a status board located in CIC. Be sure to show and label the AW axis and sectors. Also show reference points and significant points of land should, along with the scale of the plot.

In figure 10-5, the tactical arrangement is a circular formation (the small circle labeled "AW") with the "Guide" being a cruiser in station 0 (the center of the formation). The formation's center bears approximately 135° and 6,000 yards from the center of the plot. The formation is moving at a speed of 15 knots on an axis and course 000°. The wind is from 350°at 15 knots. The AW sectors originate at the center of the formation, relative to the AW axis (in this case true north) and are described as follows:

Sector Delta	000-120
Sector Echo	120-240
Sector Foxtrot	240-000

The general procedure for plotting a surface contact (Skunk B in figure 10-5) is as follows:

1. At 1803, the surface search radar operator detects a contact and reports it over the 21JS S/P circuit: "Surface contact (or Skunk)—025—24,000—one small."
2. The plotter immediately notes the time, marks a small "x" at the reported bearing and range, and records the time in four digits. (Subsequent plots use only two digits for minutes. Four digits are used again on the even hour.)
3. The plotter draws the symbol for an unknown surface contact (a square) near the plot and places the raid designation (B) near the symbol. This designation is retained for internal usage. After the contact is reported to the OTC, it will normally be assigned a four-digit track number.
4. The plotter then places the estimated size of the contact in a box near its designation (in this case, "1S").
5. The plotter will usually maintain the track at 1-minute intervals until the contact fades (in this case, time = 1812) or until he receives an order to cease tracking.
6. A minimum of three plots (2 minutes) is necessary to obtain an initial course and speed. A 3-minute plot is better because it gives a better

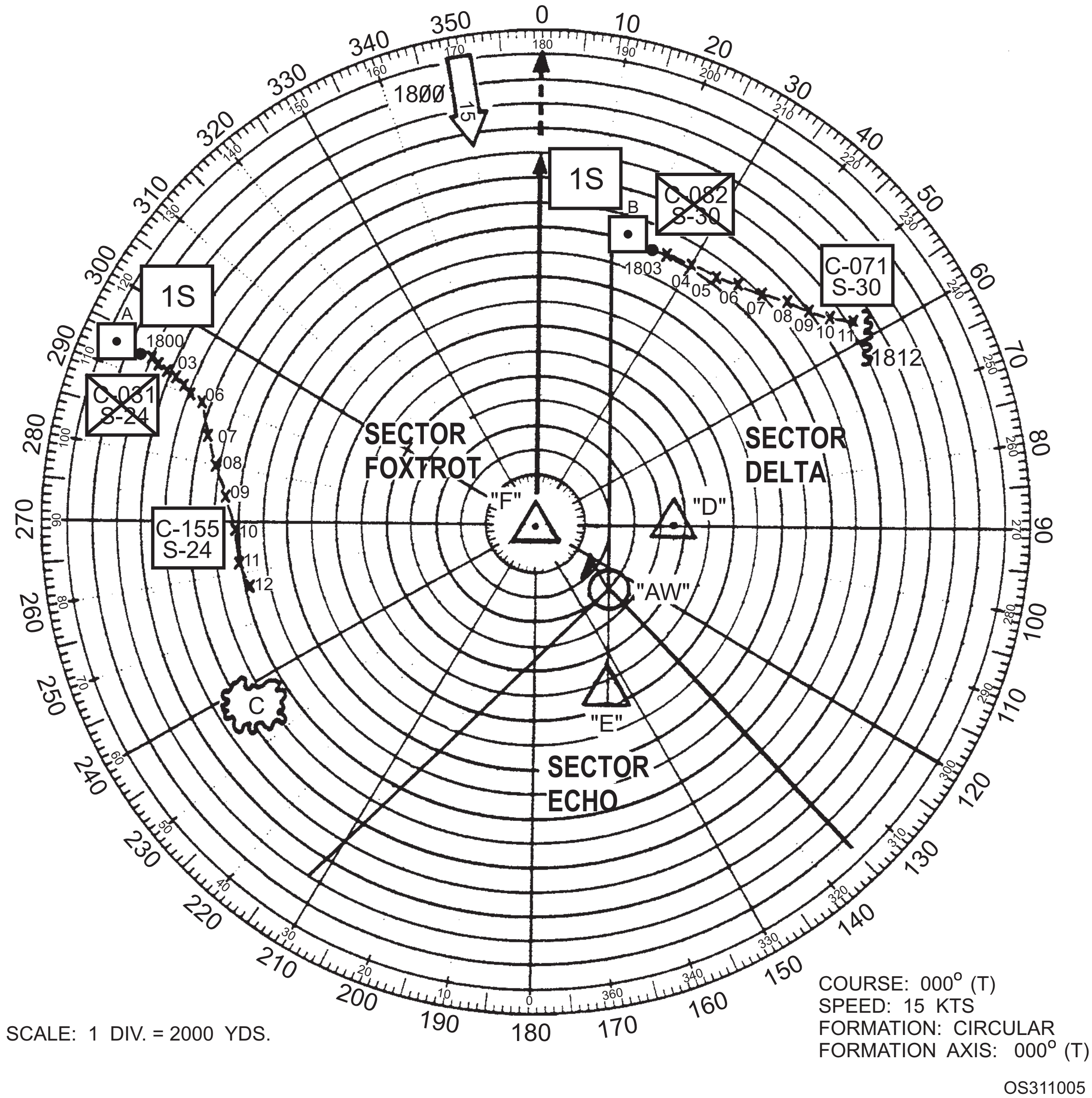

Figure 10-5.—Example of a surface summary plot.

picture of contact movement and enables use of the 3-minute rule for finding speed.

7. Course and speed are usually determined by the geographic plotter, who reports the information to the summary plotter, who then displays it in a box along the track at the appropriate time. When the plotter receives a corrected course and speed, he enters the new information in a box and crosses out the old.

8. The surface plotter (on a maneuvering board) also determines course and speed, and the contact's bearing, range, and time of its CPA to own ship.

The surface plotter also determines, when directed, the course and speed for own ship in order to intercept or avoid a contact, the course to new station, the direction and force of the true wind, and the course and speed to obtain the desired wind. We will discuss these and related subjects in chapter 11.

FORMATION DIAGRAM

A formation diagram shows the station of every ship in the formation. It is kept in polar coordinates relative to the formation's axis and center, with formation's center located at the center of the plot. As with the surface plot, it is desirable to keep the formation diagram on a vertical, edge-lighted board, but space and personnel limitations often require the use of a maneuvering board instead. Figure 10-6 illustrates a formation diagram.

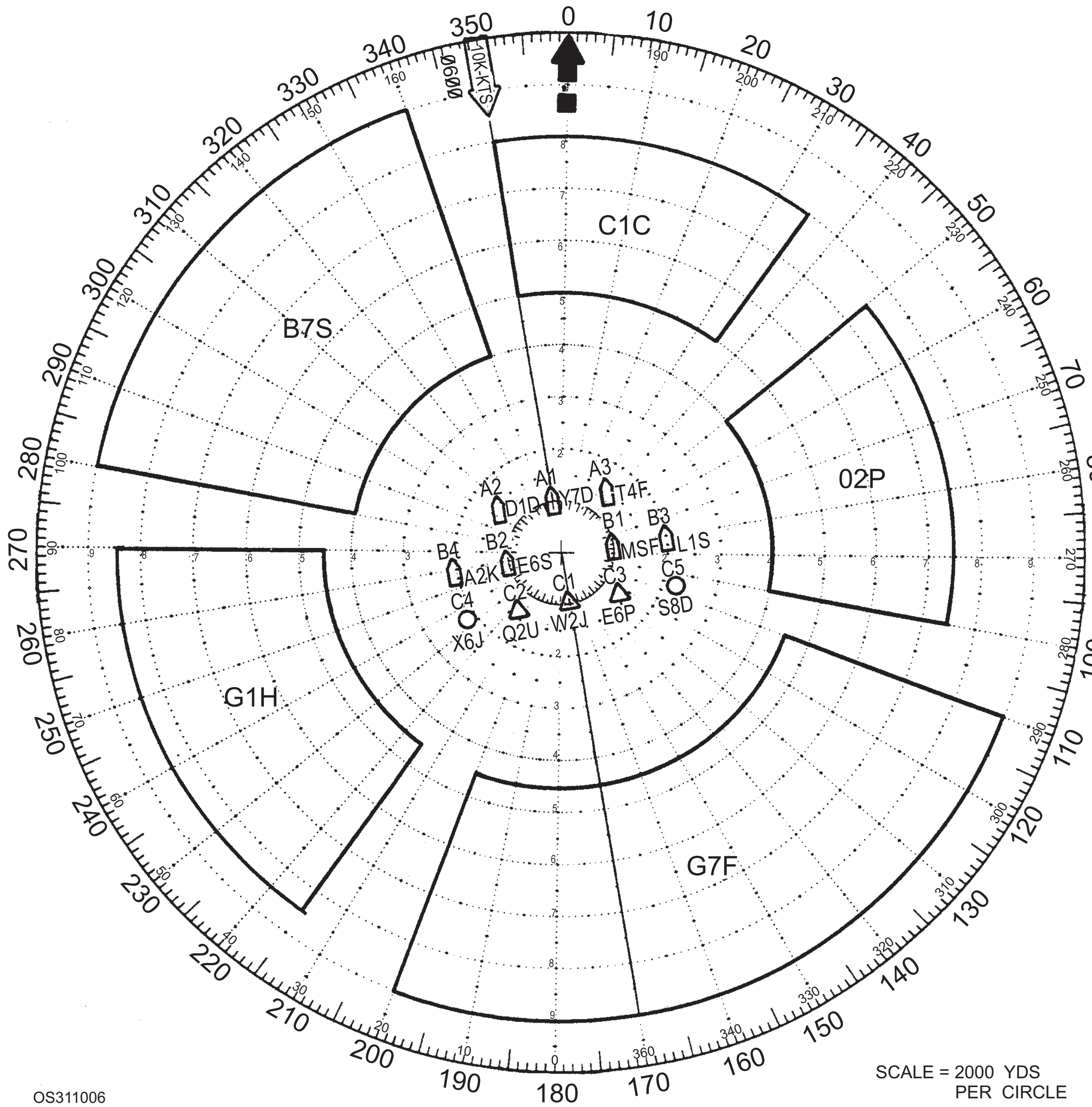

Figure 10-6.—Example of a formation diagram.

The main body is shown, with each station number and the call sign of the ship occupying that station. Screen sectors are also shown with the call signs of assigned screen units. Sector boundaries are drawn from two groups of four numerals each, specified in a tactical message. Look at the sector in figure 10-6 occupied by unit "O2P". In the assigning message, this sector was specified as "0510-0815 DESIG O2P". The first two numerals of the first group indicate the true bearing in tens of degrees of the left boundary (050°); the second two numerals indicate the right boundary (100°). The second group indicates sector depth. The first two numerals indicate the inner limit (8,000 yards), while the second two numerals indicate the outer limit (15,000 yards) of the sector from the formation or screen center.

Whenever a change in the formation occurs, a new diagram must be plotted and the surface plot corrected accordingly. Any change that affects the relation between own ship and the guide (e.g., a change in own station assignment) must be plotted immediately and the new bearing and range to the guide determined. The surface plotter determines the course to the new station.

Sometimes it is necessary to combine the surface plot and the formation diagram. In this event, two different scales and plotting colors are used. Red is normally used for the surface plot; black for the

formation diagram. The two scales MUST be displayed prominently.

SURFACE STATUS BOARD

Surface status boards contain the following data for surface plotters and other CIC personnel: cruising formation; formation axis, course, and speed; position and intended movement (PIM); and own ship bearing and range of the guide. The sector assignments of other ships in the formation may also be included.

The exact form of the surface status board varies from ship to ship. Figure 2-5, chapter 2, shows an example of a typical surface status board.

STRATEGIC PLOT

The strategic plot is a large-area true display showing the position, movement, and strength of own and enemy sea, land, and air forces within a prescribed area of operations. This display is maintained on hydrographic charts of suitable scale. Its information is taken from the operation plans and orders, intelligence data, and reports of reconnaissance missions. The strategic plot is used in planning present and future operations and in making decisions. It should contain the location of own and enemy submarines, own submarine restricted areas, enemy missile-launching sites (including all data on type and numbers), and other strategic data that may affect the tactical situation.

Q3. What surface plot displays a true picture of surface ship movement?

Q4. *What information is contained on the formation diagram?*

AIR PLOTTING

The objective of air plotting is to present a neat, accurate, up-to-the-minute picture of the positions and tracks of all aircraft in the area under surveillance.

Displays and status boards are of primary importance during air warfare operations. As for surface displays, we make no attempt to prescribe their exact format. Their size, location, and specific content are based on each ship's mission, available space, and arrangement of equipment.

In the following topics concerning air plotting, we will discuss procedures for tracking air contacts; standard air plotting symbols and abbreviations; methods for computing courses and speeds; and procedures for designating raids, making raid estimates, and plotting altitudes, fades, and splits.

AIR SUMMARY PLOT

Air plotting is done on the air summary plot, sometimes called the *vertical plot* or just the *air plot*. The air summary plot is a vertical, edge-lighted, 60-inch transparent plastic board scribed in the same manner as the surface summary plot. Depending on the amount of coverage desired, each circle might equal 1, 5, 10, 20, or 50 nautical miles. Normally, the 20-miles-per-circle scale is used so that coverage is out to 200 miles.

Air plotters man the 22JS sound-powered telephone circuit connected to the radar operators. Radar operators read the range and bearing of contacts from the scope and provide information on the contact's altitude, size, IFF code, splits, jamming, and any other data available. If the radar operator does not provide this information, the air plotter must request it, in order to figure the course and speed of contacts.

Air plotters normally work from the back of the board. Hence, you must learn to write and plot backwards so the information you plot can be read and understood easily from the front of the board.

You will use different colored grease pencils in writing on the summary plot's plastic surface. Most ships adopt a color scheme such as:

- Red or orange for hostiles or unknowns;
- Yellow for friendlies; and
- White for picket ships, patrol aircraft, and other ships in the formation.

The air summary plot is used as (1) a visual display for easy evaluation, (2) an aid in controlling aircraft, (3) a tactical picture of the air situation, and (4) a source of information for weapons liaison personnel.

The tracks of friendly combat air patrol, attack, search, observation, rescue, and other aircraft are plotted to assist in the overall evaluation and action required. The display also assists in helping lost planes get home and in establishing the position of a downed aircraft.

Although the air summary plot is basically a picture of the air situation, it also shows surface forces relating to the air picture. Reference points, dangers to air navigation, wind direction and velocity, position of the sun, positions of outlying picket forces, and raid

designations are also presented on this board. Figure 10-7 illustrates some of the information shown on an air summary plot.

Information displayed on the air summary plot comes from several sources. The principal source is the ship's air search radar, augmented by the radar of other ships in the force, picket ships, and AEW aircraft. For all CICs to have the same information, data is exchanged over both voice radio and data links.

Plotting Symbols and Abbreviations

The primary reason for using plots is to make important tactical information available, at a glance, to personnel who need it. To ensure that such information is presented in the same way every time, Operations Specialists use a set of standard air plotting symbols and abbreviations. The symbology, based on historical use and the Naval Tactical Data System (NTDS), is divided into three fundamental types:

- One based on a *square* to indicate an "unknown" contact,
- One based on a *circle* to indicate a "friendly" contact, and
- One based on a *diamond* to indicate a "hostile" contact

These symbols are divided by track types, with the upper half of the symbol indicating an air contact **(insert "unknown", "friend", and "hostile" air symbols)**, the whole symbol indicating a surface contact **(insert "unknown", "friend", and "hostile" surface symbols)**; and the lower half of the symbol indicating a subsurface contact **(insert "unknown", "friend", and "hostile" sub symbols)**. Thus, the symbols **(insert "friend surface", "hostile air", and "unknown sub" symbols)** indicate a friendly surface contact, a hostile air contact, and an unknown subsurface or submarine contact. Figure 10-8 lists the NTDS symbology most commonly used for manual air plotting.

All symbols written on plots must be large enough to be seen easily by anyone standing 14 or 15 feet from the plot.

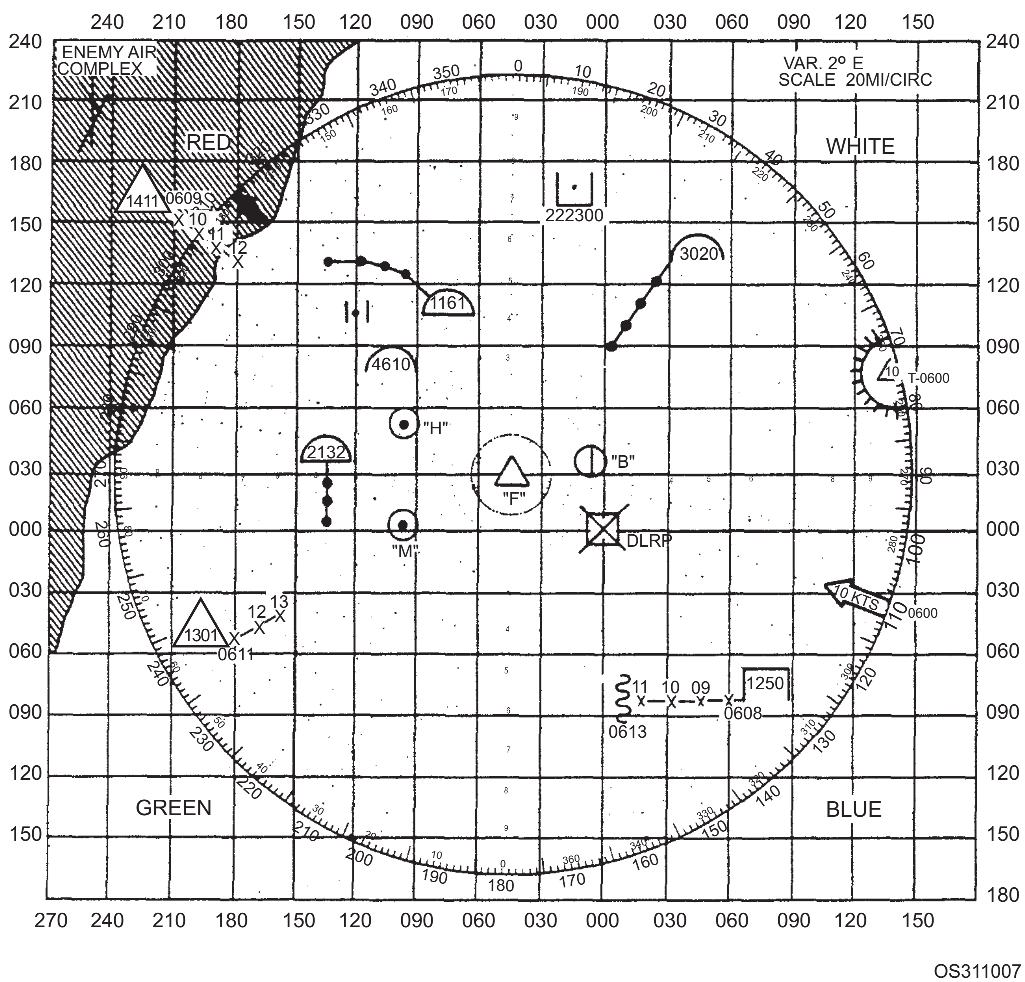

Figure 10-7.—Example of an air summary plot.

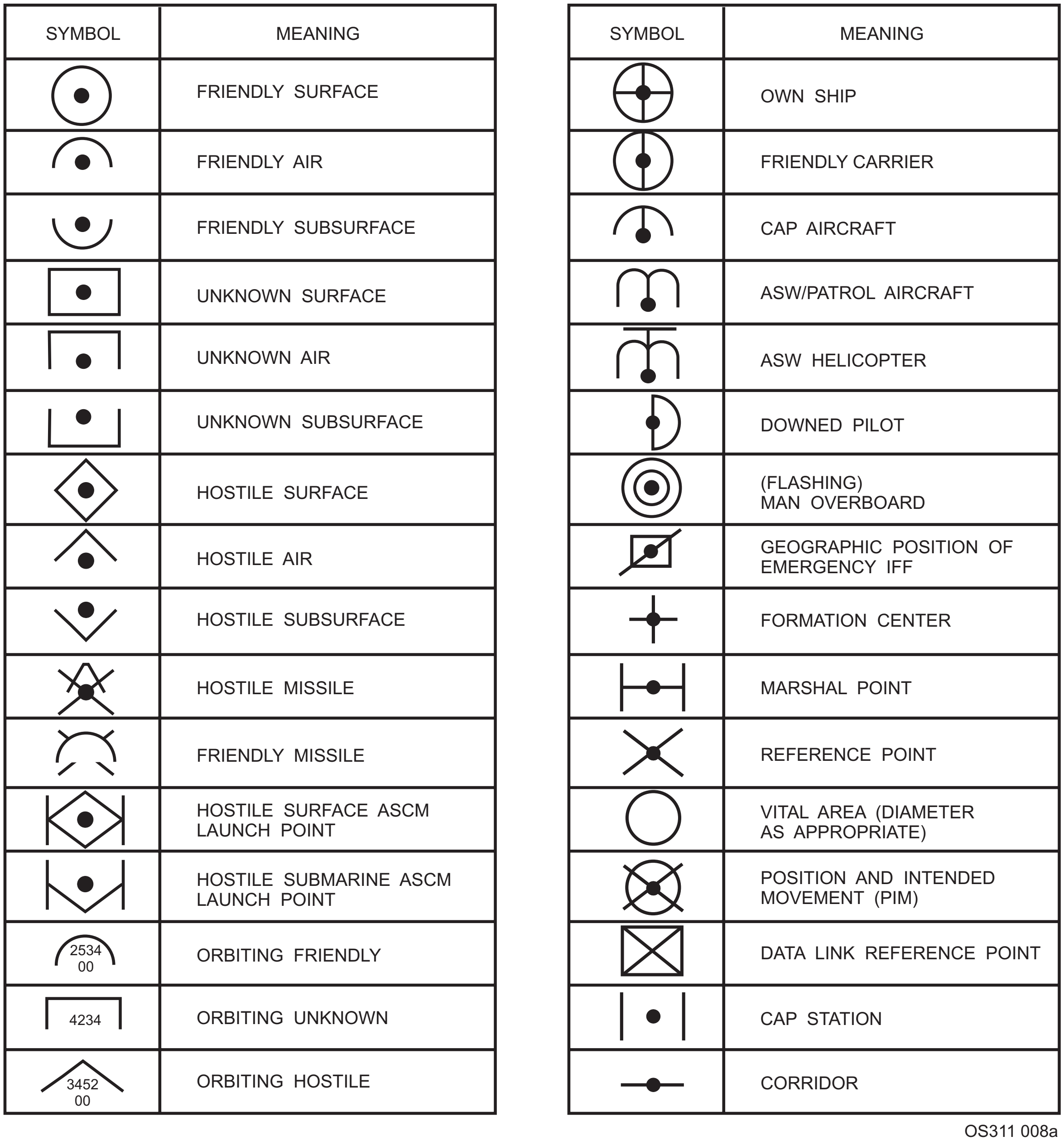

Figure 10-8.—NTDS symbology for use in manual air plotting.

Until an air contact is identified, it is referred to by the term *bogey* and is assumed to be an enemy contact. It is indicated by the "unknown" air symbol and has its position and direction of movement indicated by a series of "X"s. If the bogey is identified as friendly, its "unknown" symbol will be changed to a "friendly" symbol. If it is identified as hostile (positively identified enemy contact), its "unknown" symbol will be changed to a "hostile" symbol. All bogeys are treated as hostile until they are identified.

If the radar operator needs to report a friendly and a bogey at the same position, he will use the term *merged plot*. The symbol for a merged plot is an arrow enclosed in a circle. Merged plots occur most frequently when friendly aircraft intercept an enemy or unidentified raid and begin an air reconnaissance and/or battle.

Plotting Technique

Because of the importance of tactical information, a plotter cannot hesitate in plotting the proper symbol at the correct range and bearing. Thus, to ensure rapid and accurate plotting, you must be completely familiar with the symbols and abbreviations used in air plotting.

Immediately upon receiving a contact report from the radar operator, you should do the following:

1. Place your grease pencil at the correct range and bearing, then quickly plot an X for unknowns

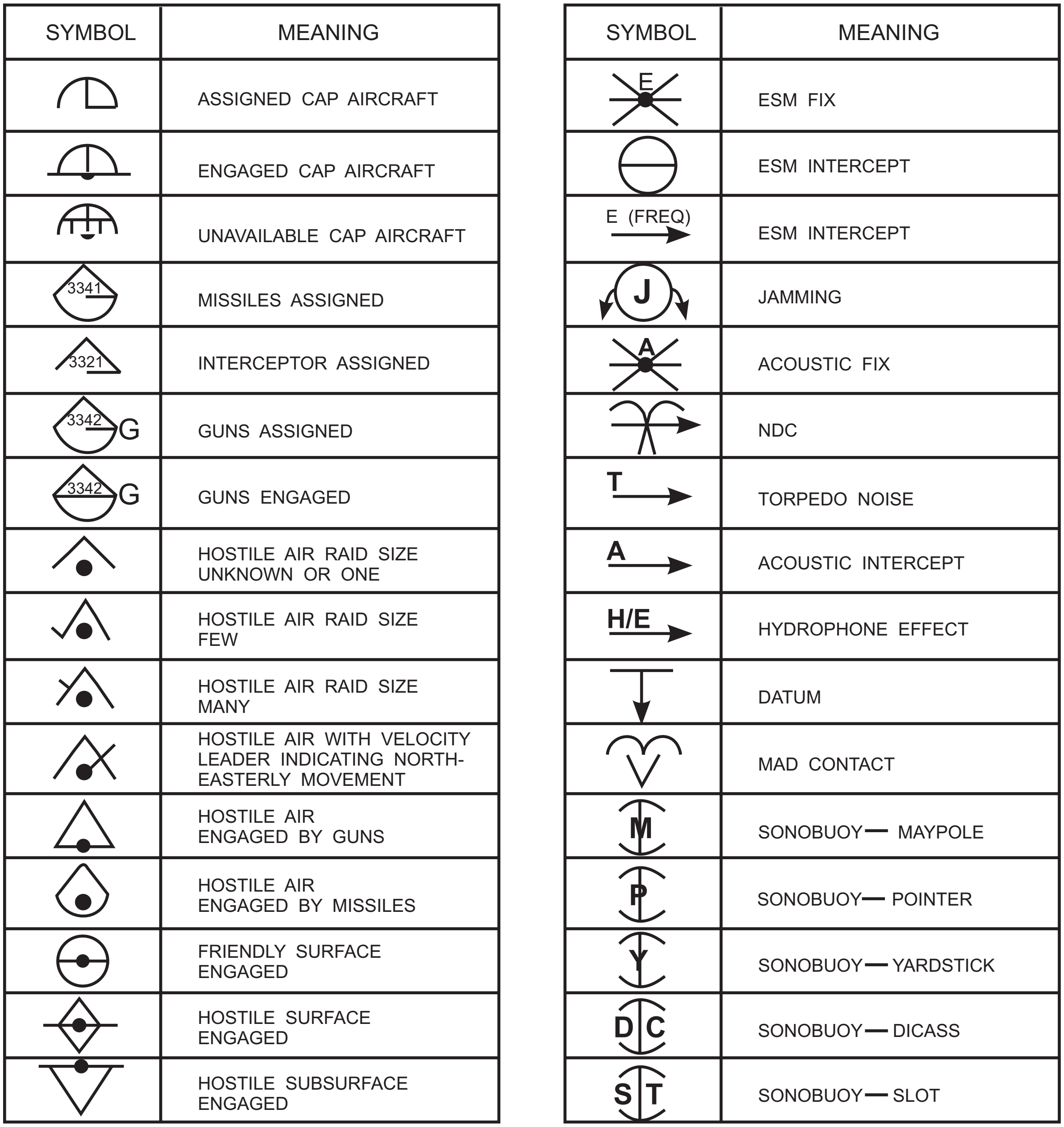

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Figure 10-8.—NTDS Symbology for use in manual air plotting (Continued).

and hostiles; use a small dot connected by a line for friendlies.

2. Alongside the plotted position, record the time you received the report. Use a four-digit time (i.e. 0923) for the first mark and marks on the hour; use a two-digit time (to indicate minutes; i.e. 24, 25, 26, etc.) for all other marks.
3. Place the proper symbol at the head of the track to indicate contact's identity.
4. Connect successive plotted positions with a line between the Xs that mark the succeeding positions.

AW units are assigned station letter designators to be used as AW unit call signs. Air raids are designated alphanumerically by the unit making the detection, using the unit's station letter designator followed by numerals commencing with figure 1, as D1, D2, and the like. Bogeys detected by NTDS units will be assigned track numbers. In addition, a designated NTDS unit will assign track numbers to all alphanumerically designated bogeys, and from then on, the bogey will be referred to by track number.

The code words *bogey*, *hostile*, or *friendly*, followed by the alphanumeric designation or track number, will be used to report the raid.

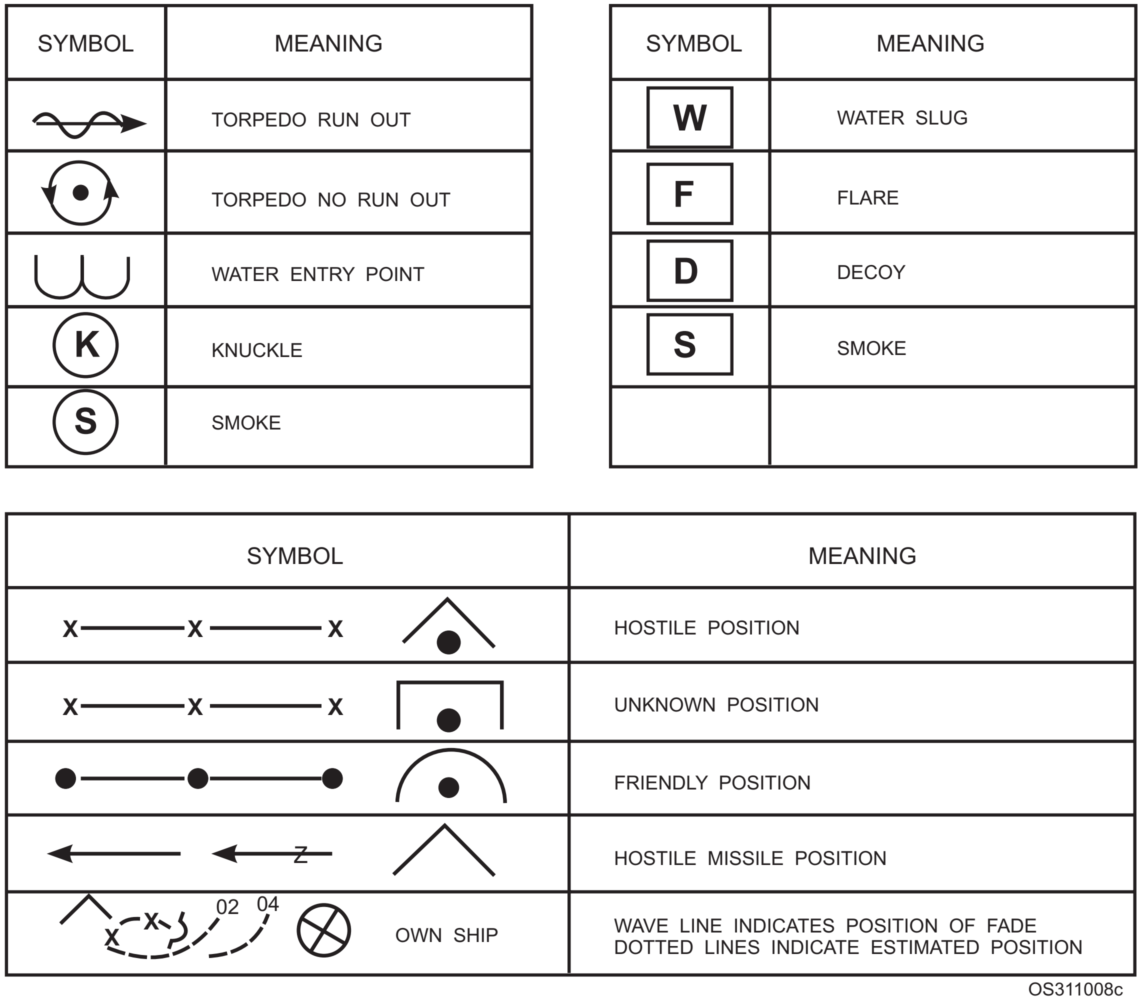

Figure 10-8.—NTDS Symbology for use in manual air plotting (Continued).

To keep a neat plot, you may wish to use a plastic template, especially for drawing raid designation symbols. To obtain a neat symbol, merely place the template against the plotting board and mark through the proper hole with a grease pencil.

Fades

Sometimes a bogey you are tracking will disappear from radar. When this happens, you should plot a *radar fade*. The aim of fade plotting is to present all possible positions at which the bogey might reappear. Because we are interested chiefly in the bogey's advance toward the formation, you should draw the fade plot with this objective in mind.

To plot a radar fade, draw a wavy line about 1-inch long, just beyond the bogey's last plotted position, perpendicular to the direction of the track. When the bogey reappears, place a similar wavy line on the track side of the plot where the bogey reappears. Then join the two plots by a solid line in the usual manner. In some instances, you may need to plot an estimated position (EP) for the bogey.

Splits

If a raid splits, the separate parts of the raid are assigned separate designations by the unit that reports the split. The part of the raid that most nearly maintains course and speed retains the previously assigned designation. The other part (or parts) is assigned the next consecutive alphanumeric designation of that unit. Those reported by TDS units are given track numbers.

Plotting Friendlies

When a contact is picked up by the radar operator, it is designated "unknown." When the contact shows proper IFF, it is re-designated "friendly" and the friendly symbol is placed at the head of the track. This contact is then listed in the appropriate area of the tote board, such as "CAP" or "strike".

When a ship is assigned a combat air patrol (CAP) to control, plotters must ensure that information concerning the CAP is kept up to date. Information displayed on the plot enables the evaluator to provide the anti-air warfare commander and friendly units information required to coordinate defensive weapons.

Computing Course and Speed

Whenever you plot a contact, obtain and plot its course and speed after the first 3 minutes of track and checked them frequently thereafter to ensure that you note any significant changes. Use a minimum of four plots (3 minutes of track) for the initial solution of course and speed. If the contact is beyond a range of 20 miles, use a minimum of three plots (2 minutes of track) to ascertain a change in course and speed. If the contact is within a range of 20 miles, you may use two plots (1 minute of track).

Course is the mean line between a number of plots and normally is computed to even tens of degrees. Figure 10-9 illustrates how to find course and speed. Compute speed as soon and as accurately as possible. Depending upon the contact's range, you can obtain its speed from 1 minute of plot, but of course, this method is not as accurate as a speed determined over longer periods. The longer the track, the more accurate your speed estimate. The most satisfactory compromise is to determine the distance (in miles) the contact covers in 3 minutes of track and then to multiply that distance by 20. (In 3 minutes, the contact will travel 1/20 the distance it will travel in 1 hour.)

TOTE BOARD

As the performance characteristics of aircraft increased over the years, the surveillance area around a force had to be expanded to allow defensive forces more time to respond to threats. Today's high-performance aircraft make it necessary to greatly extend the surveillance area. In a high activity situation, many more contacts than in the past may have to be plotted on the air summary plot. If all necessary information about every contact (speed, altitude, composition, etc.) were put on the air summary plot, the display would be so cluttered that it would be of no practical use to the evaluator or to anyone else.

The solution to this problem is to place part of the information on another plot called a *tote board*. The tote board (figure 10-10) contains all of the amplifying information on every air contact plotted on the air summary plot and is maintained by one to four persons, depending on the type of ship and the situation. The tote board contains three sections—bogey, CAP, and other friendlies.

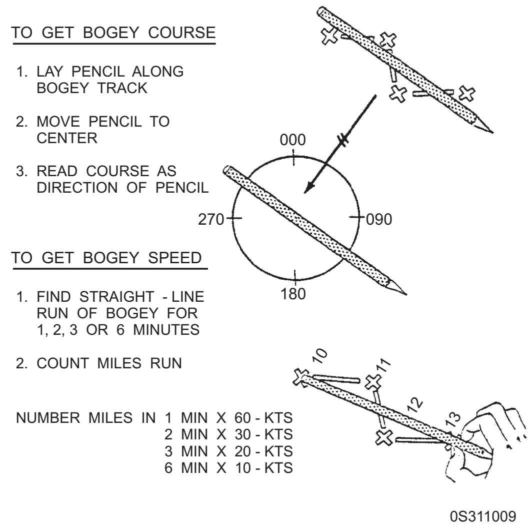

Figure 10-9.—Air contact course and speed.

BOGEY	TN	CSE	SPD	ALT	COMP	TIME	WEAPONS ASSIGNED			REMARKS
							CAP	BIRD	GUN	
T4F2	0315	170	350	23	1	1723	✓			BADGER
T4F-3	0320	255	325	30	1	1725	✓			RAK-4

CAP						OTHER FRIENDLIES	
CALL	TN	ANG	STATE	STATION	TIME	TN/CALL	REMARKS
SB201/203	0275	24	160-4-0-2	270ZZ60	1715	0251	TANKER
GS110/107	0261	30	150-4-4-0	000ZZ-60	1715		

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Figure 10-10.—Example of a tote board.

Ideally, the tote board is located next to the air summary plot. The two boards together form the complete air summary display. The main plotter is located behind the board and plots all of the amplifying data on own ship's radar contacts. He or she usually figures the course and speed of each contact by measuring the distance and direction traveled in a certain period of time on the air summary board, and receives composition and altitude information on sound-powered phones from the radar operator. The main plotter receives other amplifying information from the RCO or the air controller.

One or two plotters, located in front of the board, plot amplifying data on air contacts as it is received from other ships on R/T nets. On ships that have a limited number of personnel, the R/T plotter-talkers who are plotting on the front of the air summary plot may also have to maintain the tote board. If sufficient personnel are available, a second plotter can be placed behind the board to plot data on friendly aircraft. The main plotter can concentrate on only bogey data.

Since the tote board illustrated in figure 10-10 is an example, it can easily be modified to include more friendly information as required. The upper section of the tote board pertains to bogeys and includes alphanumeric designation, track number, course, speed, altitude, composition, time, and weapons assigned. The remainder of the board is devoted to friendly air contacts, such as CAP and strike aircraft. Contained in this section is information on the CAP, for example, the call sign, track number, assigned altitude, state (fuel and weapons on board), station (a number, code word, or bearing and range), and time. For other friendly aircraft, the call sign or track number and mission (under "Remarks") are all that is necessary.

The tote board plotters must actually work on two separate boards—the tote board and the summary plot. In performing their duties, they must do the following:

1. Watch the summary plot and list new bogeys on the tote board under the "Bogey" section.
2. Use their grease pencils to measure the distance the raid traveled in a certain time by contacts on the summary plot, compute speed, and determine course.
3. Receive bogey composition from the radar operator and record it under the "Bogey" section.
4. Record altitude of the raid. (Depending on circumstances, this height figure may come from own radars or from the CAP. If it comes from the CAP, the plotters will receive the data from the air controller via the RCO.)
5. Record any information relayed to them by the R/T net plotter, the link 14 plotter, and the air controller.

CONVERSION PLOTTING

Various methods of making position reports are in use today in anti-air warfare operations. Some of these methods are (1) latitude and longitude; (2) grid systems; and (3) bearing and distance from own ship, another designated ship, or from a specified point. You may have to use any of these three basic methods to report positions. You may also have to convert information in one system to equivalent information in another system. For example, you may have to translate raid positions received in the task group's coordinate system to polar coordinates for weapons target designation. The OTC will normally specify the most suitable reporting method in each situation.

Even when you don't have to convert information from one system to another, you may have to convert information within the same system. For example, you may have to convert range and bearing information of own ship's radar to range and bearing information for another ship in the task group. The simplest and quickest way to do this is the parallelogram method.

Figure 10-11 shows the parallelogram method. Suppose point A represents own ship and point B represents the flagship, bearing 070-30 miles. Own ship picks up and plots bogey X, bearing 010-50. Your task is to report the bearing and range of the bogey from the flagship, B. To solve the problem quickly, place a pencil on the imaginary line that connects B and X. Note the distance from B to X. Now move the pencil parallel to line BX until it lies over point A. Note the point (C) that is located the same distance from point A that point X is located from point B. Read the range and bearing of point C from point A. By the rules of a parallelogram, this is also the range and bearing of point X from point B. In this problem, bogey X bears 333° at a range of 43 miles from the flagship B.

You can also use the parallelogram method to convert a contact position you receive from another ship to own ship reference. Suppose the flagship, B, gave you the range and bearing of bogey X from B. How do you determine the range and bearing of X from own ship? First, plot (or use your pencil to determine) point C from point A using the same range and bearing

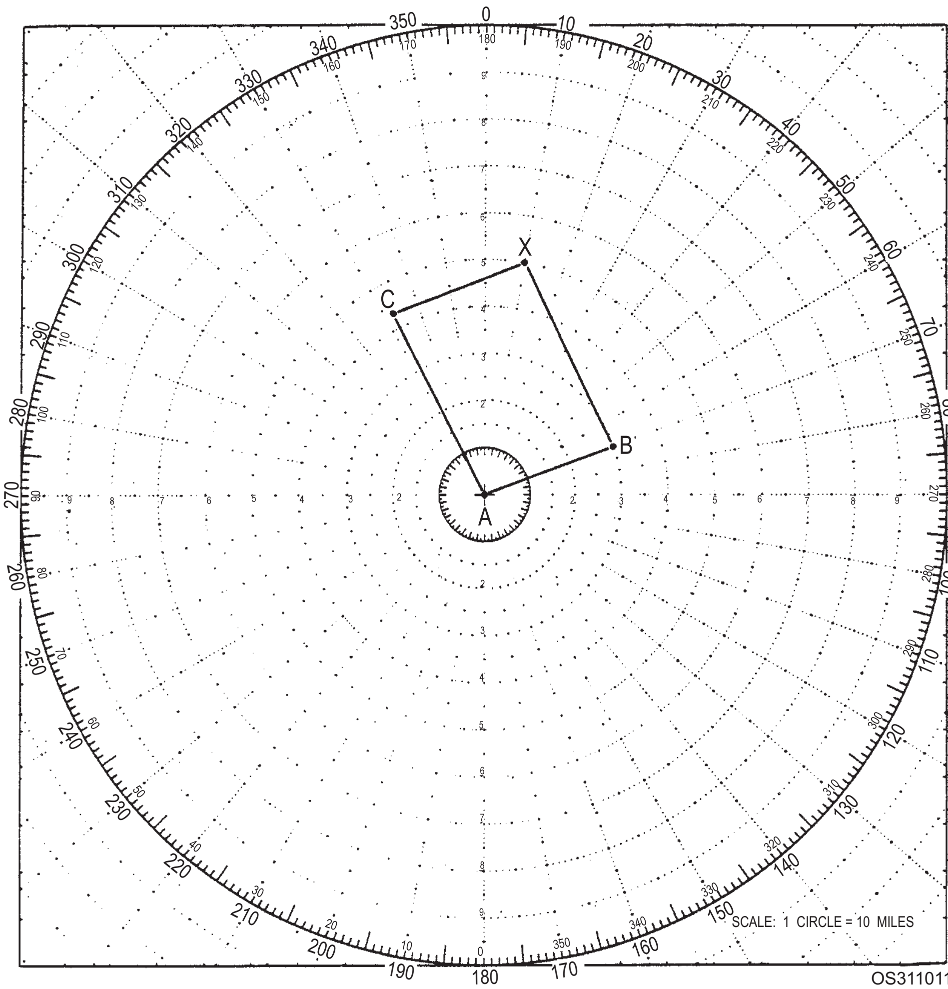


Figure 10-11.—Example of a conversion plot.

information supplied by the flagship. Now move a line equal in length to line AC parallel to AC until the "point A" end of the line coincides with point B. Mark the "point B" end of the line at the new location. This point is the location of bogey X. Finally, determine the range and bearing of X from own ship, A.

Q5. What scale is normally used to set up an air summary plot?

Q6. What information is plotted on a tote board?

ASW PLOTTING

Two of the key figures in maintaining the display of the ASW tactical situation are the DRT plotters. The DRT plot is the heart of ASW operations in CIC. It displays much more than the location of the submarine and the surface ships; it also records other vital information, such as hydrophone effects, weapons launched, and depth indications. The importance of having a permanent and easy-to-read record of this information is that the information often has little significance at the time it is obtained, but when the TAO/evaluator later looks over the entire operation, all of the important details come together as one significant whole. For this reason, the plotters should be highly experienced. Usually, there are two plotters—No. 1 and No. 2. The No. 1 (or south) plotter records own ship's contact and, hence, must wear the 61JS phones. The No. 2 (or north) plotter plots the assisting ship and the assisting ship's contact. He or she, therefore, must wear the 21JS phones over one ear and, at the same time, listen to the TG REPT net speaker for the assisting ship's contact reports.

DRT PLOTTING PROCEDURES

The importance of the DRT in successful ASW operations warrants a close look at the procedures and symbols used in ASW plotting.

Own Ship—Own ship's track is plotted using a circle with a cross inside. By using this symbol to mark the periodic position of the DRT bug and connecting

the plots, the plotter can determine the ship's approximate course between the several positions. Own ship's track should be plotted in black, with succeeding positions recorded on the plot at intervals of 1 to 5 minutes, based on the range of the ASW action (long-range or close-in). Occasionally, arrows should be added to show the direction of the ship's movement. Marking arrows on the plot is particularly important when the ship is working over a contact in a limited area. Because plots often crisscross, the arrows enable personnel reviewing the plot later to gain a more comprehensive picture of the ship's actual maneuvers.

Submarine—A submarine's track is plotted using the appropriate submarine symbol. On every report from sonar, a plot must be made of the true position of the submarine. (This plot can be a dot with the symbol plotted at 3- to 4-minute intervals.) The submarine's track should be recorded in either black (friendly) or red (unknown or hostile), with succeeding positions recorded on the plot at intervals necessary to maintain a proper plot (1 to 3 minutes).

Assist Ship—The assist ship is plotted in blue with the surface friendly symbol. Subsequent positions should be plotted as necessary to clarify the plot.

As assist contact reports are received, they are plotted in red, with an X inside the contact symbol indicating that the report came from a ship and a small square indicating that the report came from an aircraft. Assist contact reports are less frequent than own ship's contact reports, so time may be plotted as the reports are received over the radio.

When contact is lost, the plotter dead reckons the contact, and the TAO/evaluator orders search arcs. Dashed lines indicate the DR track.

Other important symbols consist of squares or circles enclosing a letter. One of these symbols is an encircled K, representing a *knuckle*, a sharp turn made by a ship using its engines or heavy rudder. This symbol serves as a reminder in later operations through the same area that sonar may receive echoes from the water disturbance.

Another situation calling for a distinctive symbol is when a submarine emits a water slug, flare, smoke, or decoy that creates sonar echoes. (A slug is ejected air that rises to the surface and can be seen easily because of the resultant discoloring of the surface water.) These items are plotted as a square with the appropriate letter (W, F, S, or D) inside the square.

EMERGENCY PLOTTING

During ASW operations on most ships, if a casualty occurs on the DRT, the plotters should use the Halifax plot described in chapter 9 (see figure 9-8). Before the Halifax plot is used, the DRT paper should first be lightly marked off with parallel north-south and east-west lines about 2 inches apart.

Emergency plotting procedures call for more plotters. An own ship's plotter, using the plotting scale, the ship's tactical data (templates, if possible), and information supplied by the ship's information talker, maintains a plot of own ship's position. The plotter keeps the plotting scale properly oriented underneath the DRT paper, with its center below own ship's position. At the same time, other plotters record information on the submarine and the coordinating ship(s).

The ship's information talker, stationed next to the plotting table, uses a stopwatch to provide *Mark* signals every 15 seconds. At these intervals he also announces the ship's course, speed, and rudder to enable own ship's plotter to maintain the track.

The regular south plotter is responsible only for plotting the submarine at 15-second intervals. The north plotter performs the same functions as in regular plotting except that, instead of using the DRT bug, the north plotter uses the plot of own ship's plotter as a point of reference.

Several variations of the Halifax plotting procedure have been used in the fleet. The procedure described below is one of those, but individual ships may find it necessary to introduce modifications to suit their own needs.

When the TAO/evaluator gives the order "Commence emergency plot," the ship's information talker sets his stopwatch at the start of the next 15-second interval of the CIC direct reading clock. He announces "Mark" and own ship's present course, speed, and rudder. He continues to call "Mark" and gives this information at 15-second intervals.

At the first *Mark*, own ship's plotter, who has the plotting scale correctly oriented under the DRT paper, marks own ship's position. If at all possible, the ship should maintain a speed of 15 knots while emergency plotting is in progress, to support dead reckoning. At this speed, the 1/2-inch circle of the Halifax plot represents the distance traveled in 30 seconds. Turns must be plotted on the basis of the ship's tactical data.

The sonar supervisor receives the initial mark from CIC and starts his stopwatch. With a system of “Stand by—Mark” signals, he ensures that a range and bearing to the submarine are supplied to the north plotter every 15 seconds via the sonar information circuit.

Using red pencil and plotting symbols, the north plotter plots each submarine position.

The south plotter, at each “Stand by—Mark” signal given by the information talker, receives from the radar repeater operator a radar range and bearing to the assist ship. As soon as the north plotter plots the submarine information, the south plotter plots the coordinating ship.

Own ship’s plotter then moves the plotting scale to the next 15-second position of own ship.

The surface scope operator must have the radar repeater at the proper range setting for marking the assisting ship, which may be close to own ship at times during the operation. The surface scope operator wears the 21JS sound-powered phones and marks the assisting ship, ships of the SAU (Search-Attack Unit), and helicopters or Skunks for the No. 2 plotter and the maneuvering board operator. During weapon attacks (ASROC), the surface scope operator also marks the water entry point if it is seen on the scope.

Q7. During ASW plotting, what sound-powered phone circuits do the north and south plotters talk on?

Q8. What color and symbol should the plotter use to plot an assist ship on the DRT?

TARGET MOTION ANALYSIS AND PASSIVE LOCALIZATION

Target motion analysis (TMA) is a method of tracking a submarine by using information obtained by passive means. This section presents single-ship TMA procedures and is organized to present a logical flow through the TMA process. We begin with definitions, symbols, acronyms, abbreviations, and a list of the plots used in the TMA process.

Silent search sonar information usually consists of an indication of the contact’s bearing and, sometimes, clues to its classification. Several methods have been developed that rely on target bearing information to obtain the contact’s range, course, and speed. The process of calculating these values is called target motion analysis (TMA). You must understand the inputs, basic assumptions, and underlying principles of the TMA process and methods to implement these methods effectively and to interpret their results.

Figure 10-12 is a summary of the TMA symbols and parameters (fire control values) that are used in this chapter. A graphic example is provided to assist in visualizing each parameter.

LINE OF SIGHT (SOUND) DEFINITIONS AND SYMBOLS

To develop an understanding of TMA, you must learn the line-of-sight (LOS) diagram. It is an essential tool to help you visualize the motion relationship between own ship and the target. Most TMA techniques break target and own ship motions into various components in and across the line of sight in order to measure or compute various quantities. Figure 10-13 is the basic LOS diagram. It shows the various components of own ship and target motions used in TMA.

In practice, the LOS diagram is a simple, logical, and orderly method of viewing the relationship of own ship and the target ship during all phases of approach and attack. It is an instantaneous vector picture that shows own ship and the target ship oriented about the LOS common to both ships. Figure 10-14 illustrates components of the line-of-sound diagram.

The LOS (view A) is the line from own ship to the middle of the target. The distance from own ship to the middle of the target (view B) is the range (R). Target course (C_t) vector (view C) extends in either direction through the longitudinal axis of the target and is determined by angle on the bow. Own ship’s course (C_o) vector (view D) extends from the engaged axis (the end of own ship pointing toward the target). When the lines representing target course and own ship’s course are extended (view E), a target vector and an own ship vector result.

Presented in view E is a complete LOS diagram showing symbols of LOS, C_t, C_o, R, LA, and A_b. Any change in these values results in a corresponding change in the LOS diagram. In conclusion, it can be said that this diagram shows an instantaneous and constantly changing picture of the relative positions of own ship and the target.

ANGLE ON THE BOW

Angle on the bow (A_b) is the relative bearing of own ship from the target, expressed in angles up to 180° port or starboard of the target’s bow. Although

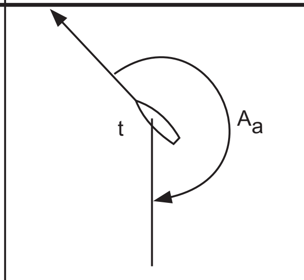
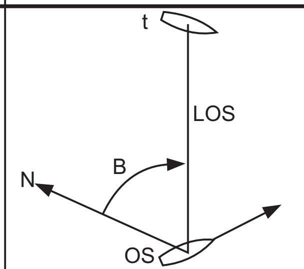
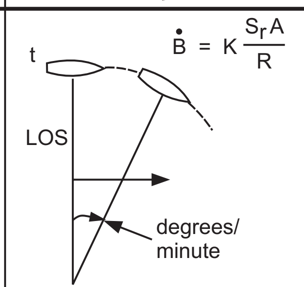
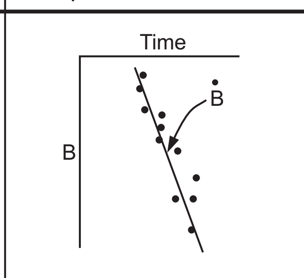
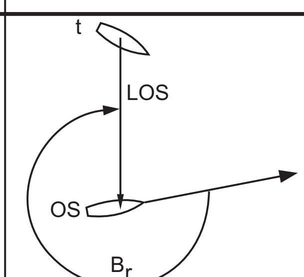
SYMBOL	TERM	EXAMPLE	DEFINITION
A_a	ASPECT ANGLE (TARGET ANGLE)		THE ANGLE BETWEEN THE VERTICAL PLANE THROUGH THE TARGET SPEED VECTOR AND THE VERTICAL PLANE THROUGH THE LINE OF SOUND.
B	TRUE TARGET BEARING		THE ANGLE FROM NORTH TO THE LINE OF SIGHT MEASURED CLOCKWISE THROUGH 360°
$\dot{B}$	BEARING RATE INDICATE RIGHT OR LEFT		THE RATE OF CHANGE OF TRUE TARGET BEARING, EXPRESSED IN DEGREES PER MINUTE, MEASURED RIGHT OR LEFT IN THE SAME DIRECTION AS S_tA
$\bar{B}$	FAIRED BEARING		A LINE FAIRED THROUGH A SERIES OF RAW BEARINGS. MATHEMATICALLY, A LEAST-SQUARES SOLUTION.
B_r	RELATIVE TARGET BEARING		THE ANGLE FROM OWN SHIP'S COURSE AND SPEED VECTOR TO THE LINE OF SIGHT, MEASURED CLOCKWISE FROM THE BOW THROUGH 360°

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Figure 10-12.—TMA symbology and definitions.

both angle on the bow and target angle are determined by relative bearing of own ship from a target, they differ in this respect: Angle on the bow is measured 0° to 180° port or starboard from target bow, whereas target angle (A_a) is measured clockwise from the target bow in a full 360° circle.

When you know own course and relative target bearing (see figure 10-12), angle on the bow makes it possible to determine the true course of the target.

True target course (C_t) is determined in the following manner: Take the reciprocal of true target bearing (own ship's true bearing from target) and

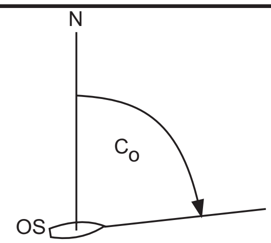
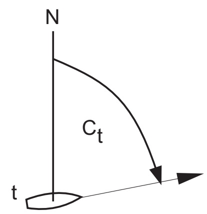
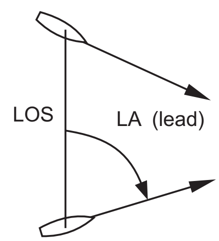
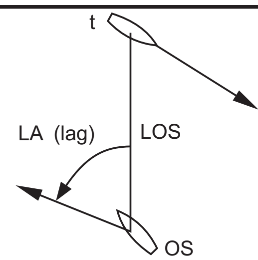
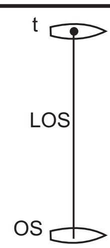
SYMBOL	TERM	EXAMPLE	DEFINITION
C	SPEED OF SOUND	NONE	SPEED OF SOUND IN WATER - EXPRESSED IN FEET PER SECOND
C_o	OWN SHIP COURSE		THE ANGLE FROM NORTH TO OWN SHIP'S TRACK MEASURED CLOCKWISE THROUGH 360°
C_t	TARGET COURSE		THE ANGLE FROM NORTH TO OWN SHIP'S TARGET TRACK MEASURED CLOCKWISE THROUGH 360°
LA	LEAD ANGLE		ANGLE MEASURED FROM THE LINE OF SIGHT TO OWN SHIP'S TRACK (0° TO 180°)
	LAG ANGLE		WHEN OWN SHIP'S TRACK IS NOT INCLINED IN THE DIRECTION OF TARGET MOTION, IT IS CALLED A LAG ANGLE
LOS	LINE OF SIGHT		A LINE FROM OWN SHIP TO THE TARGET

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Figure 10-12.—TMA symbology and definitions (Continued).

subtract the angle on the bow; the difference is true target course. When visual sighting is impossible, angle on the bow can be calculated from estimated target course based on one of the sonar plots (discussed later in this chapter). To obtain angle on the bow by this method, subtract target course from the reciprocal of target bearing ($B_{ts} = B_y + 180° - C_t$).

Relative angle on the bow (A_{br}) is defined as the angle measured from the direction-of-relative-motion (DRM) line to the line of sight or sound (LOS). Its use comes into play extensively when you use the time bearing and relative motion plots and the bearing rate computer. You can easily understand relative angle on the bow if you consider a target that is on a collision

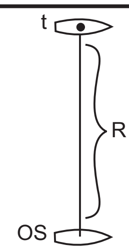
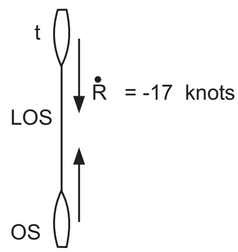
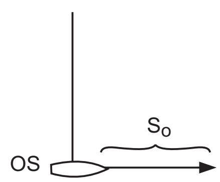
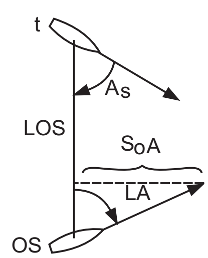
SYMBOL	TERM	EXAMPLE	DEFINITION
R	RANGE		THE DISTANCE FROM OWN SHIP TO THE TARGET
$\dot{R}$	RANGE RATE PREFIX: +OPENING -CLOSING		THE ALGEBRAIC SUM OF S_tI AND S_oI EXPRESSED IN KNOTS OR YARDS PER MINUTE. R MUST BE PREFIXED + FOR OPENING RANGE OR - FOR CLOSING RANGE.
S	SPEED		MOVEMENT THROUGH THE WATER EXPRESSED IN KNOTS OR YARDS/MINUTE
S_o	OWN SHIP SPEED		OWN SHIP'S SPEED THROUGH WATER IN KNOTS
S_oA	OWN SPEED ACROSS LOS PREFIX: R RIGHT L LEFT		THE MEASUREMENT (COMPONENT) OF OWN SPEED PERPENDICULAR TO THE LOS, MEASURED RIGHT OR LEFT IN KNOTS $S_oA = S_o \sin LA$

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Figure 10-12.—TMA symbology and definitions (Continued).

course with own ship. In this situation, relative angle on the bow is zero. In another example, a target that is at its closest point of approach (CPA) has a relative angle on the bow of 90°. With respect to a target bearing rate, when A_{br} equals 0°, target bearing rate is 0, and no range solution is possible. When A is 90°, bearing rate is a maximum value. Aboard a submarine, target angle is derived by a method known as angle on the bow (A_b). Whereas the ship uses 360° for computing target angle, the submarine uses only 180°, specifying port or starboard side. For example, a destroyer has a submarine bearing 070° relative. Aboard the submarine the target angle would be reported as "Angle on the bow, starboard 70." A relative bearing

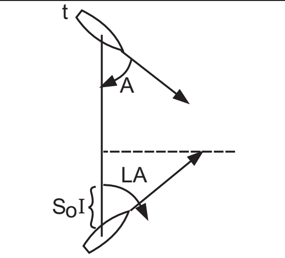
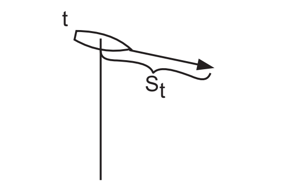
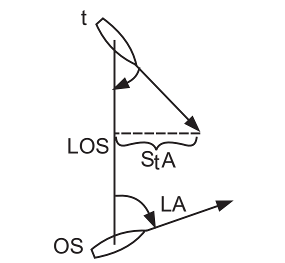
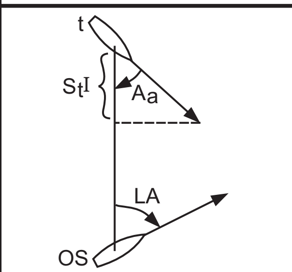
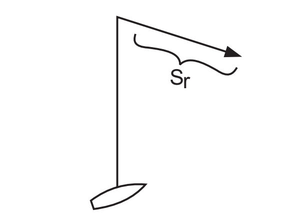
SYMBOL	TERM	EXAMPLE	DEFINITION
S_oI	OWN SPEED IN LOS PREFIX: + OPENING - CLOSING		THE MEASUREMENT (COMPONENT) OF OWN SPEED PERPENDICULAR TO THE LOS, MEASURED RIGHT OR LEFT IN KNOTS $S_o I = S_o \sin(90^o - LA)$
S_t	TARGET SPEED		TARGET SPEED THROUGH THE WATER IN KNOTS
S_tA	TARGET SPEED ACROSS LOS PREFIX: R RIGHT L LEFT		THE MEASUREMENT (COMPONENT) OF TARGET SPEED PERPENDICULAR TO THE LOS, MEASURED RIGHT OR LEFT IN KNOTS $S_tA = S_t \sin(90^o - A_a)$
S_tI	TARGET SPEED IN LOS PREFIX: + OPENING - CLOSING		THE MEASUREMENT (COMPONENT) OF TARGET SPEED IN THE LOS MEASURED OPENING OR CLOSING IN KNOTS $S_tI = S_t \sin(90^o - A_a)$
S_r	RELATIVE SPEED PREFIX: R RIGHT L LEFT		THE SPEED RESULTING WHEN OWN SPEED COMPONENTS ARE REMOVED FROM TARGET SPEED COMPONENTS

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Figure 10-12.—TMA symbology and definitions (Continued).

of 345° from ship to target is reported on the submarine as “Angle on the bow, port 15.”

BEARING RATE

Bearing rate ($\dot{B}$) is change of target bearing, in degrees per minute. It is the algebraic sum of the components of target and own ship motion across the LOS converted into angular measurement in degrees per minute. By definition, right bearing rates are positive (+); however, we use the notation *right* or *left*, not positive or negative. Therefore, all components of speed across the LOS (S_oA, S_tA, and S_rA) must be labeled right or left so that $\dot{B}$ and S_rA are always in the same direction.

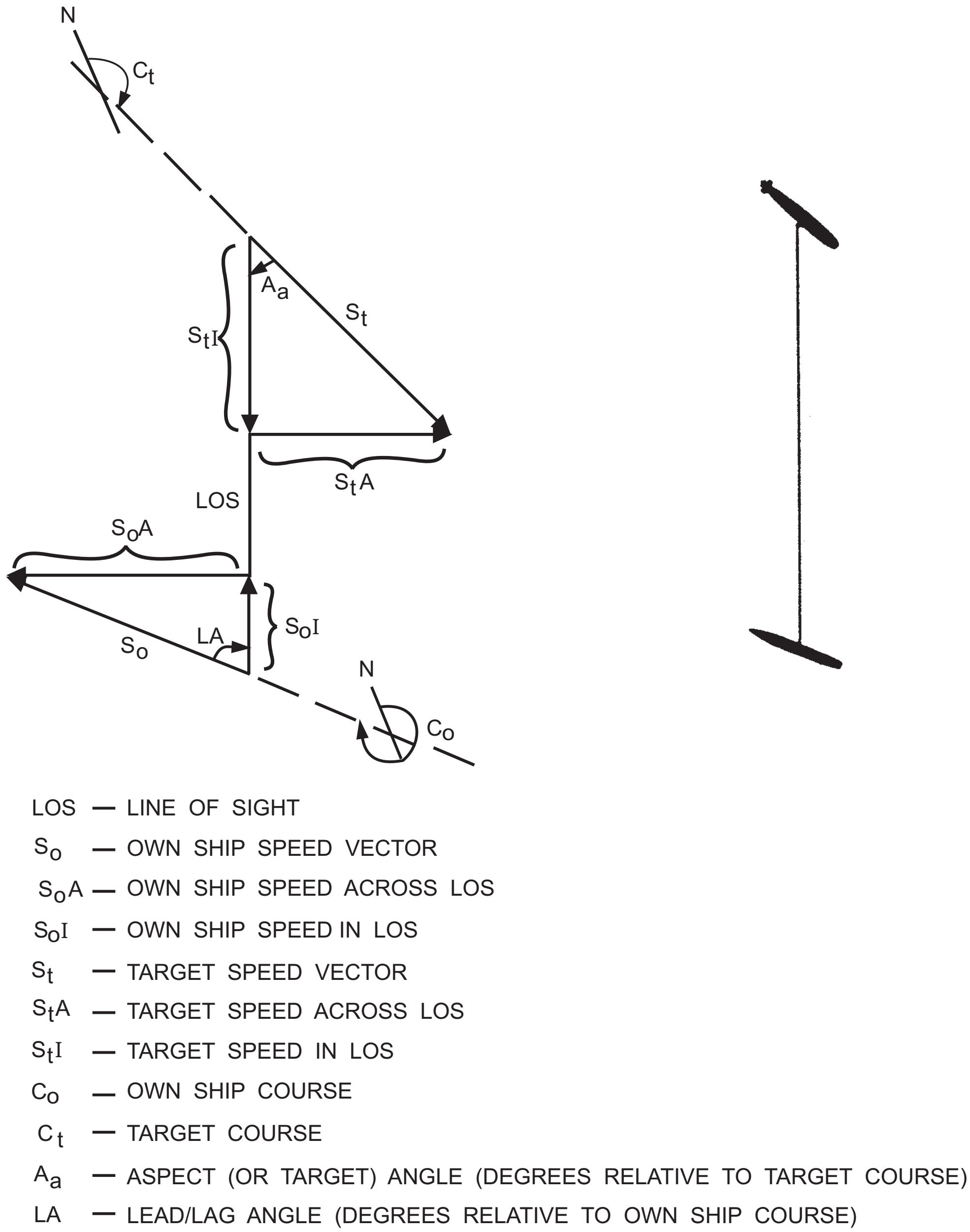

Figure 10-13.—Line of Sight/Sound (LOS) diagram.

ANALYSIS OF TARGET MOTION

Basic elements of target motion analysis are target speed, course, range, bearing, and bearing rate. Bearing rate ($\dot{B}$) is a quantity for use in developing target course, speed, and range.

Establishing Bearing Rate

The primary objective of establishing bearing rate is to calculate target course and speed. If the target cannot be observed visually, true target motion can be learned most readily by hovering or heading directly toward the target. This method is simple and results in no own ship's component across the LOS. The bow normally should be headed toward the target to produce a more aggressive approach and to avoid loss of sonar contact astern. If angle on the bow can be ascertained, direction of true target motion is known.

Once direction of true target motion is known, bearing rate can be determined by using one of the relative plots (discussed later). These plots provide certain data that can serve as known values in calculating many unknown values. These calculations are accomplished by means of a bearing rate computer.

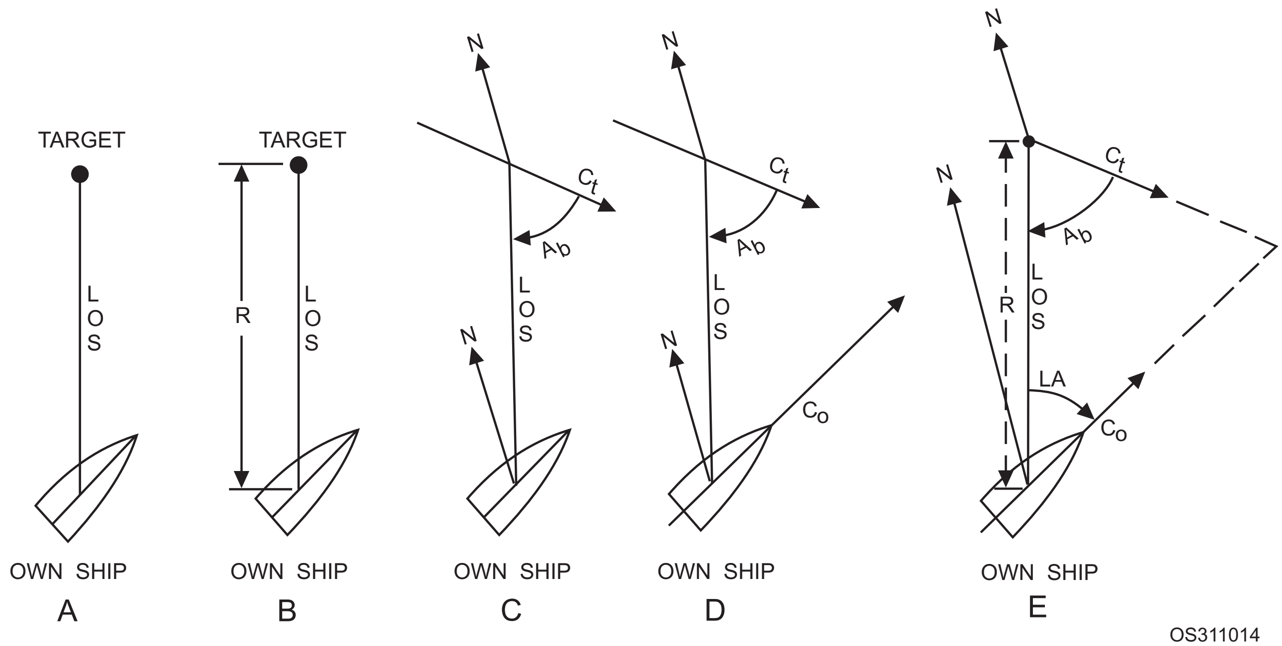

Figure 10-14.—Breakdown of LOS diagram.

Bearing Rate Computer

The bearing rate computer (BRC) is a tool used by ASW plotting personnel aboard surface ships to compute the following values:

1. Own ship's speed across the LOS
2. Target speed across the LOS
3. Target range, using total relative speed across the LOS and the bearing rate
4. Ekelund range, using own ship's speed across the LOS and bearing rate totals for two different legs

The bearing rate computer (also called bearing rate slide rule (BRSR)) is a circular slide rule consisting of two concentric discs, each scribed with two scales and a movable cursor. See figure 10-15. From the outer edge inward, these scales are target speed, bearing rate, range, and angle on the bow. Range and speed scales are inscribed on a fixed element. Bearing rate and angle-on-the-bow scales are inscribed on a movable element attached to the fixed element. For convenience in aligning the slide rule and reading values, a cursor is mounted on top of the fixed and movable scales.

Labeling of the angle-on-the-bow scale permits entering directly an angular value whose sine is desired. This angle-on-the-bow scale can be used for any angle whose sine is needed—whether bow, lead angle, deflection angle, or other angle. The 90° mark on the angle-on-the-bow scale represents the sine of 90° or 1; 30° on the same scale represents the sine of 30° or 1/2.

Time/Bearing Plot

The time/bearing curve or plot is the keystone to almost all TMA techniques. The purpose of the plot is to provide a graphical display of target motion with respect to time, giving insight into critical events as they occur as well as quantitative inputs to other TMA techniques. You can visualize the relationship of the time/bearing plot information by considering a long-range closing contact that maintains constant course and speed. If own ship also maintains course and speed, the bearing changes slowly at first, with the bearing drift (rate of bearing change) increasing gradually as range decreases. As the contact closes to CPA, the bearing rate increases more rapidly, reaching a maximum value at CPA, and then decreases as the contact opens. As the range increases, the bearing rate decreases to near zero. Figure 10-16 shows the time/bearing curve for the target and own ship tracks shown in figure 10-17. The tactically significant features of the time/bearing plot are as follows:

1. If own ship and target maintain constant course and speed, the bearing drift is always in the same direction. As range decreases, the bearing rate increases from near zero to a maximum at CPA, then decreases to zero as the range increases. The rate and direction of bearing drift depend on relative course and speed as well as range. A sharp change in the bearing rate may indicate a

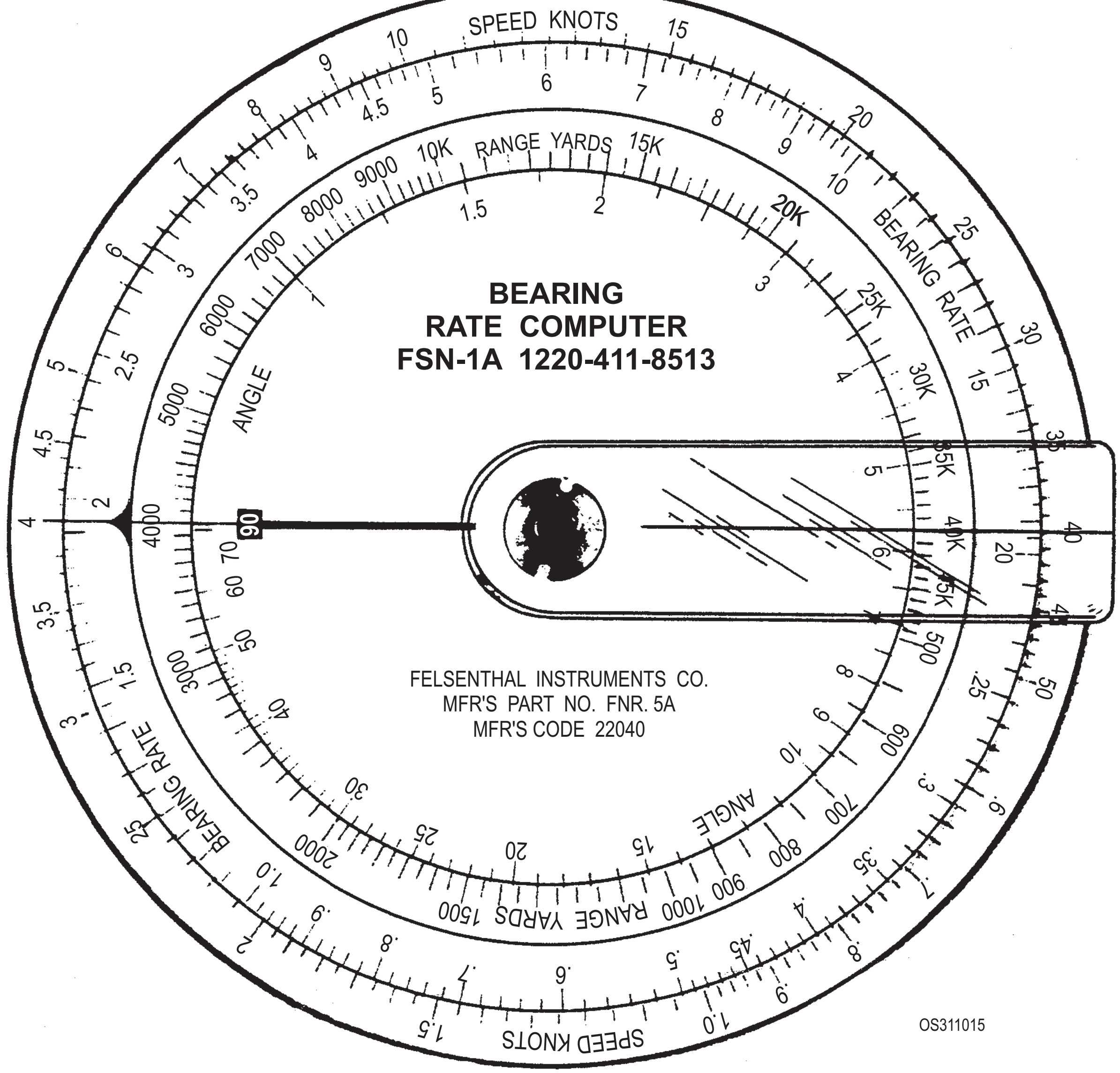

Figure 10-15.—Bearing Rate Computer (bearing slide rule [BRSR]).

target (or own ship) maneuver. A change in the direction of bearing drift, however, always indicates a maneuver.

2. The bearing rate is proportional to relative speed across the LOS and inversely proportional to range. The bearing rate at CPA can be used to estimate either the target range or speed, given an estimate of the other. A bearing rate of about 3° per minute or higher is a strong indication that the target is close enough for the TAO to consider going to an active search. Once the target has closed to active detection range, there is no further advantage to remaining in silent search, as the surface ship is extremely liable to detection by the submarine.

3. While a TMA solution is being developed, own ship should remain at a constant course and speed for 10 to 20 minutes, depending on the particular TMA method being used. Thus, the CIC team is unlikely to observe more than a segment of the total time/bearing curve, shown in figure 10-16. The segment they observe will most likely appear nearly linear, as in figure 10-18. An observable change in bearing rate or a break in the time/bearing plot that is not due to an own ship or target maneuver gives a rough indication of range when the target is near CPA. A rapid change in bearing rate, observed as an abrupt break on the time/bearing plot, indicates that the target is passing close aboard, while a less pronounced break indicates a more distant target. In general, the higher the bearing rate, the

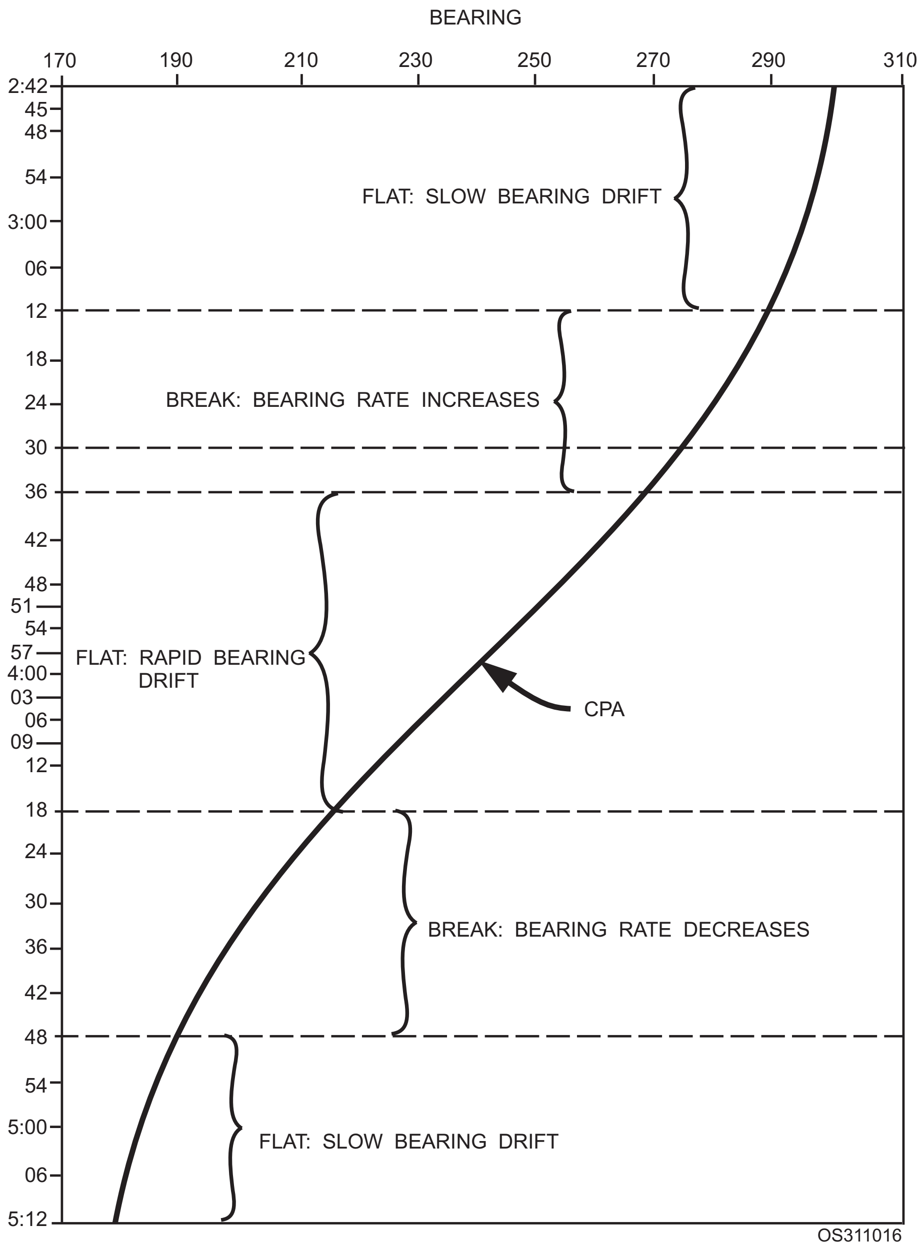

Figure 10-16.—Time/bearing curve (breakdown).

greater the probability that the target will be a short-range target. This relationship is frequently overlooked in determining the appropriateness of various passive TMA techniques versus an active sonar search. The plot supervisor must constantly examine the time/bearing plot as it develops, observing bearing rate and changes in bearing rate.

Time/Bearing Plot Equipment

Construction of the time/bearing plot requires the following equipment:

1. Plotting surface
2. Roll of 1-inch grid (graph) DRT paper
3. Bearing rate templates scaled 1" = 1 min/1" = 5°, and 1" = 1 min/1" = 1° (fig. 10-19)
4. Dividers
5. Parallel rulers
6. Number 2 lead pencils/colored pencils and gum erasers.
7. Ship’s curve if available

Plotting Procedures

Initially construct a horizontal bearing scale of 1° per inch across the top of the grid, increasing to the

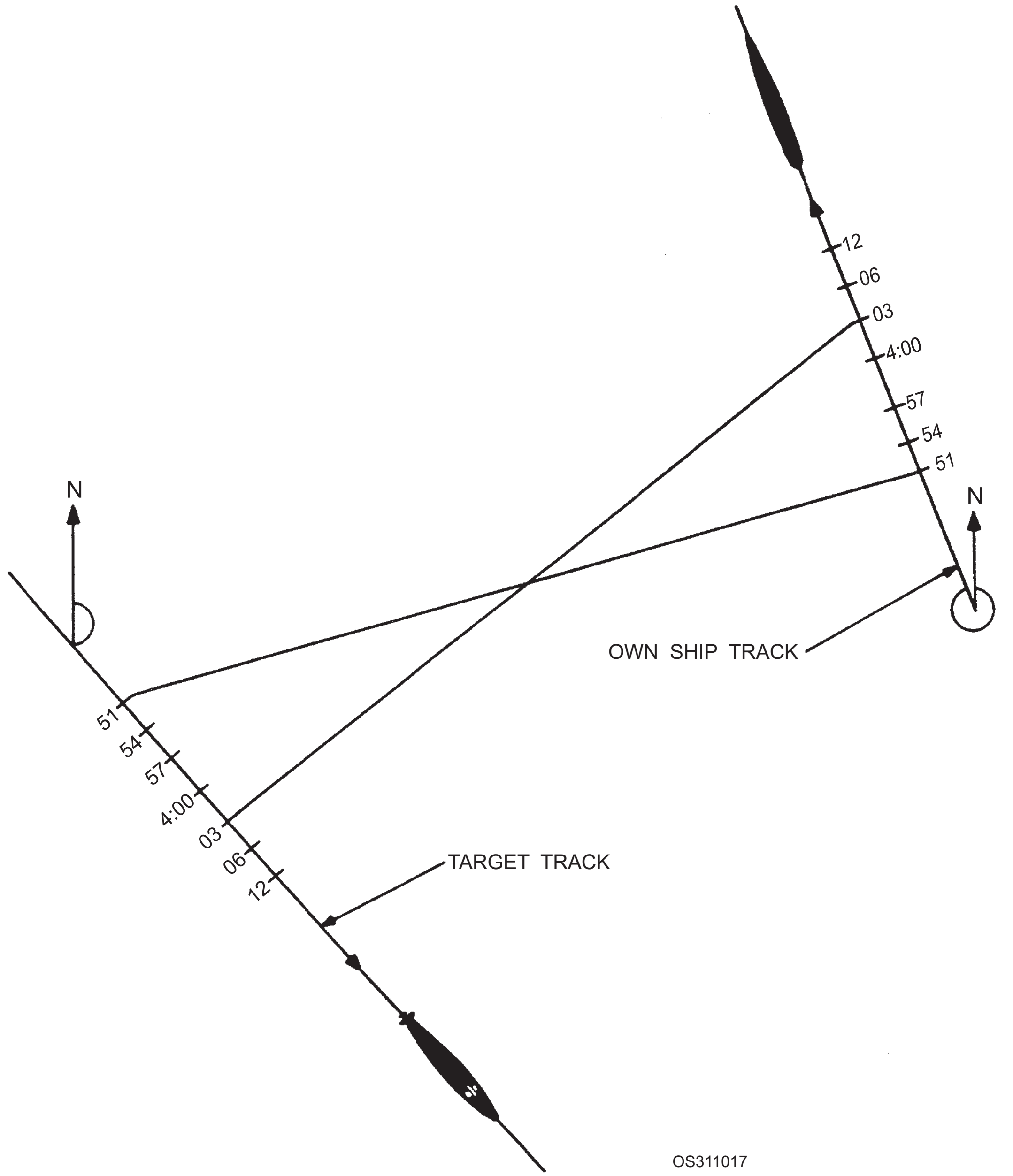

Figure 10-17.—Example of own ship and target actual tracks.

right. Mark off a vertical time scale of 1 minute per inch down the grid. If the bearing rate exceeds 3° per minute, change the horizontal scale to 5° per inch.

Plot each target bearing as it is reported. Plot the bearings as accurately as the grid will allow. The more accurate the initial bearing plots, the more accurate the solution. Figure 10-20 shows how the bearing scale and time scale are laid out on the grid for a contact with a 3º per minute or greater bearing rate.

After you observe a bearing drift of at least 5° or an interval of 10 to 20 minutes, draw a faired (average) line through the plotted points as in figure 10-18. This line helps average out the random error in raw sonar bearings. When you fair a line through bearing points, use a minimum of 10 minutes worth of data, and preferably 10 data points obtained during that time. Draw the faired line only through the first 8 minutes of points, however. Reserve the last two points as the first two points of the next set of data points through which you fair the next line. This provides continuity in target motion. If your plot includes vertically "stacked" bearings, use only the beginning data point of each stack. This may result in fairing less than the desired number of data points, but will provide a more accurate picture of target motion (fig. 10-20).

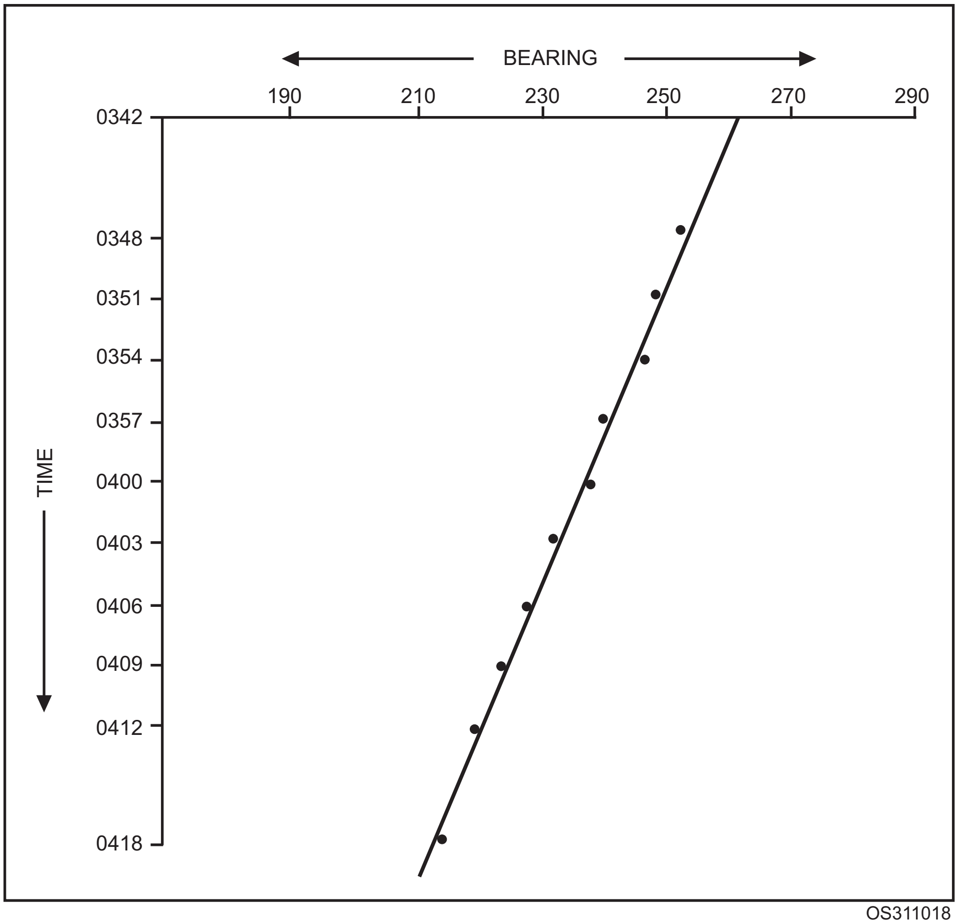

Figure 10-18.—Time/bearing plot segment.

If own ship changes course or speed, draw a horizontal line through the plot to indicate the time of the change. Resume plotting when own ship has steadied on its new course and speed. Draw another horizontal line through the plot at this time, and label this line with the new course and speed. If you are using bearings from a towed array, allow at least a time interval equal to that required to tow the array through two times its length after own ship is steady on the new course. Cross-hatch the plot during the time of the maneuver.

For each leg or segment of faired data, compute the bearing rate (slope of the faired bearing line), using a bearing rate template (fig. 10-21) as follows:

1. Select a template with a scale corresponding to the plot scale.
2. Place the zero line (center line, fig. 10-19) of the template along the faired bearing line.
3. Read the bearing rate from the line closest to parallel to the vertical line.

Another method is to set the zero scale vertically through a selected time mark and read the bearing rate ($\dot{B}$) where the faired bearing crosses the template scale.

Draw a box near the bearing midpoint of the data points that you measured. Record the midpoint bearing (B) and bearing rate ($\dot{B}$) in the box, and indicate the midpoint of the leg with an arrow. Label the bearing rate as measured either right or left.

Figures 10-22 and 10-23 show how a complete time/bearing plot will appear when plotted and labeled correctly.

NOTE

Accurate clock-time synchronization between CIC and sonar is extremely important and should be checked to the nearest second several times while passive ASW operations are being conducted.

For very-long-range contacts, bearing rates will be small (1°/min or less) and will be difficult to measure using the 1" = 1 minute time scale. In such instances, you may use a reduced time scale (for example, 5 or 10

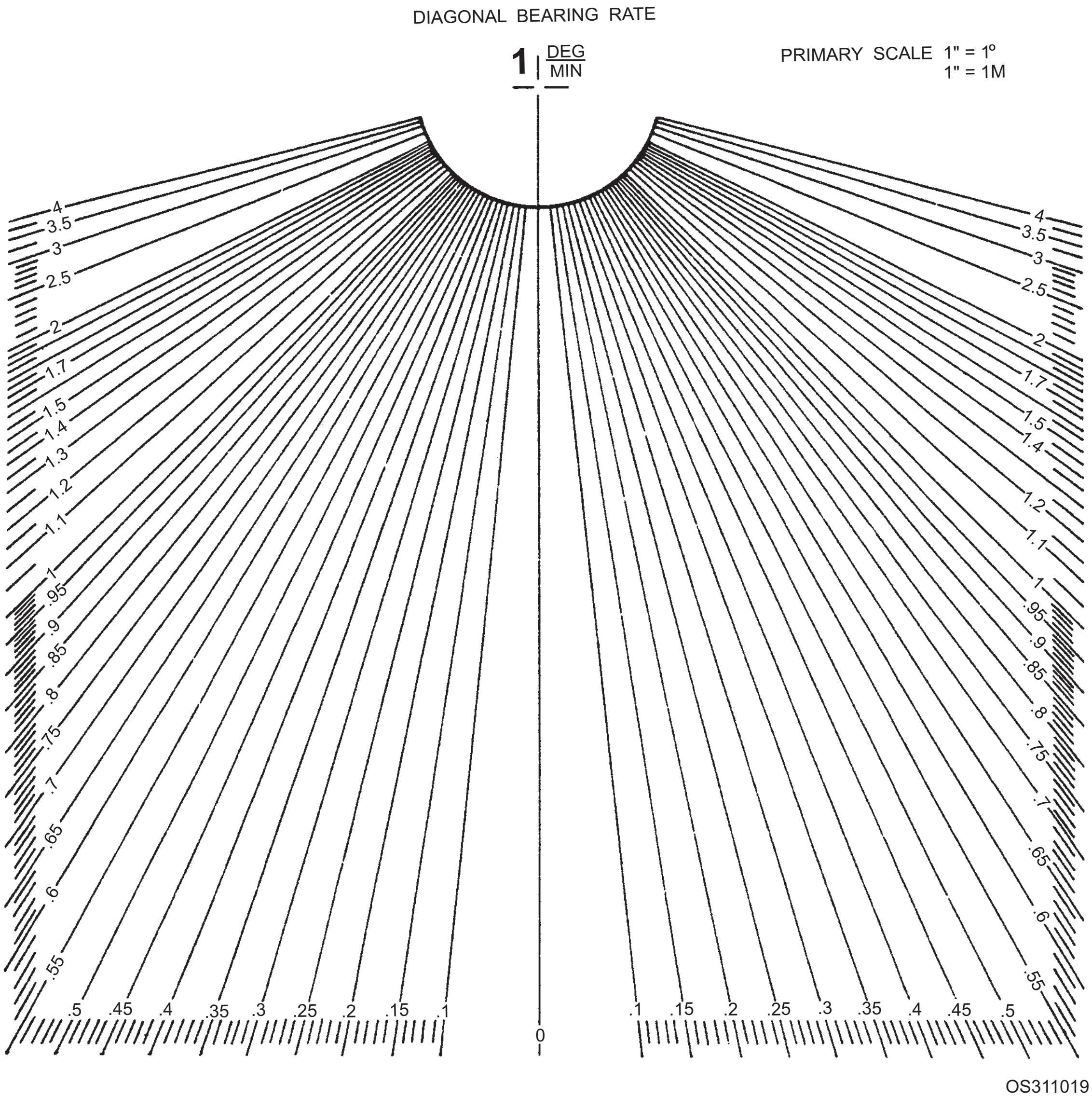

Figure 10-19.—Bearing rate template (one degree per minute).

minutes per inch) to display a greater amount of information. For extremely low bearing rates (0.5°/min or less), you may need to use up to 30 minutes or more of data to discern any evidence of bearing rate ($\dot{B}$). If you also reduce the horizontal bearing scale to an equivalent scale, you may still use the 1" = 1 min/1" = 1° bearing rate template. If the contact maneuvers during the extended plotting time, recompute the bearing rates from the point of the maneuver.

Q9. What is the primary purpose of establishing a bearing rate?

Q10. What plot is the keystone to almost all TMA techniques?

GEOGRAPHIC PLOTTING TECHNIQUES

Geographic plotting techniques attempt to estimate target course, speed, and range by fitting trial target tracks (speed strips) to a set of bearing lines drawn from own ship's position at designated times. Useful TMA information can be obtained on a single leg if the target's speed is known or can be estimated. Own ship can maneuver and extend the plot over two or more legs to obtain a complete TMA solution without an assumed target speed. As with any proven passive TMA technique, the target must maintain steady course and speed. Geographic plotting requires the following equipment.

1. DRT
2. PMP

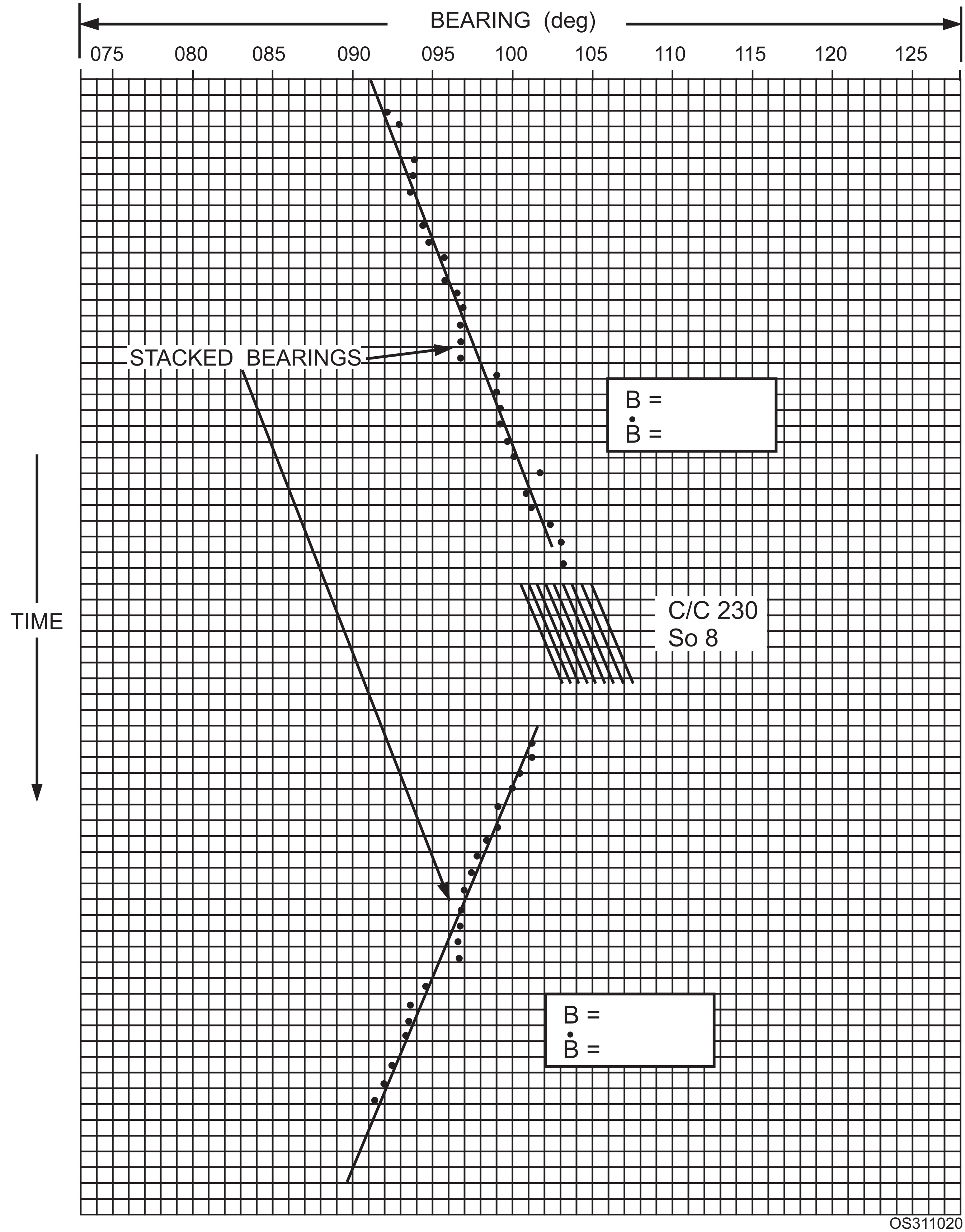

Figure 10-20.—Time/bearing plot (stacked bearings).

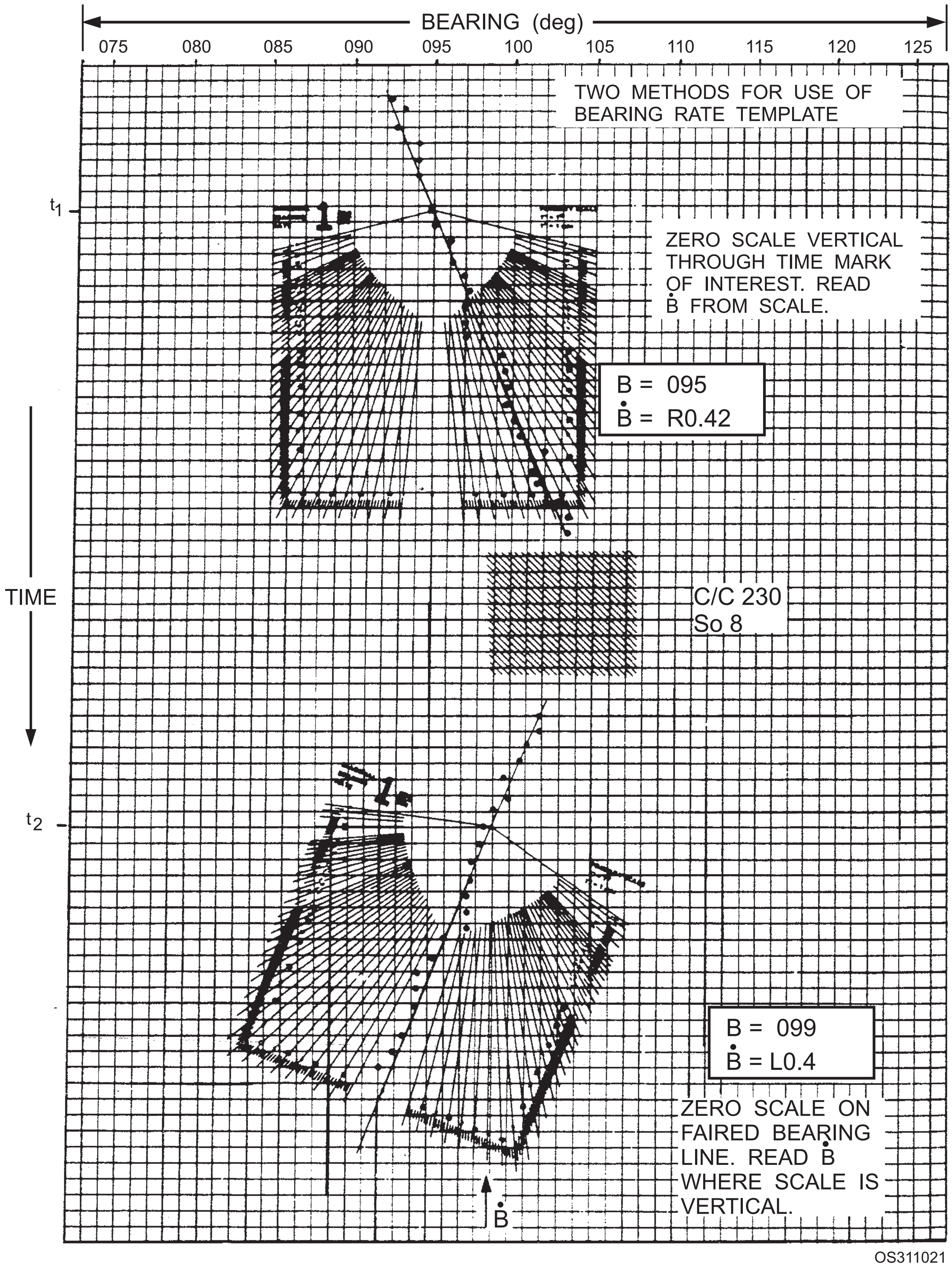

Figure 10-21.—Example of the use of bearing rate template.

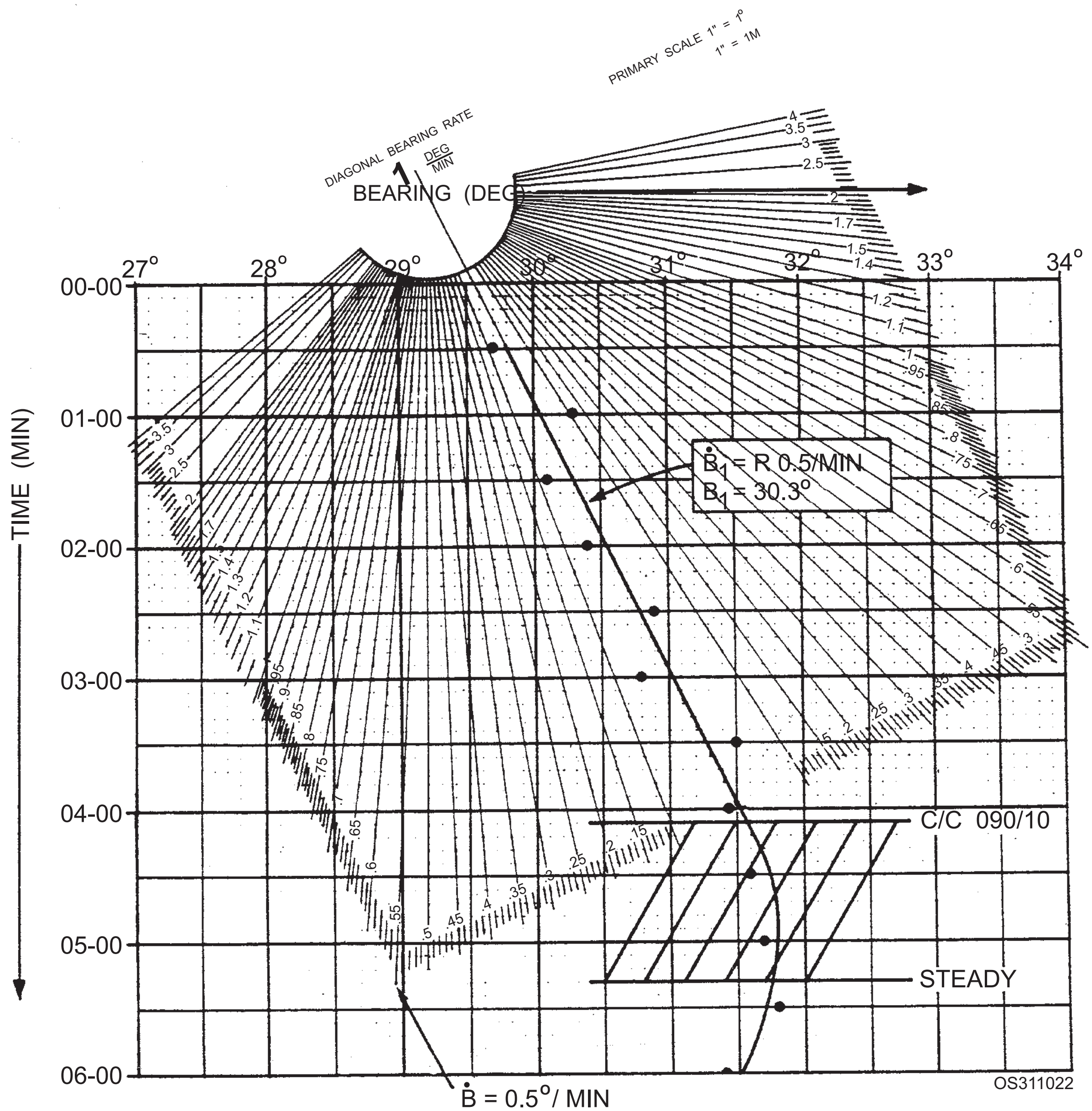

Figure 10-22.—Time/bearing plot (leg 1) measurement.

3. Tracing paper (DRT)
4. Hard lead and colored pencils
5. Gum erasers
6. Dividers
7. Speed strips from 4 to 20 knots (See figure 10-24). Speed strips should be made of transparent plastic, cut into individual strips, and placed on a ring clip.

Strip Plotting

The strip plot is a method of solving for target course and range by using an assumed target speed. In this method, target bearings are plotted out from own ship's track on a true geographic plot. Transparent plastic strips calibrated in distance per unit of time (speed strips) are fitted at various angles to the target bearing lines until the tick marks on the speed strips fit the bearing lines (fig. 10-25) and target course and range are derived.

Position the bug on the plotting table to allow maximum plotting room; that is, if the target is to the north, set the bug near the southern boundary and in the middle of the east-west direction.

Select a scale that will allow plotting the maximum target range, normally 2,000 or 5,000 yards to the inch. The sonar and TMA supervisors determine the maximum expected target range.

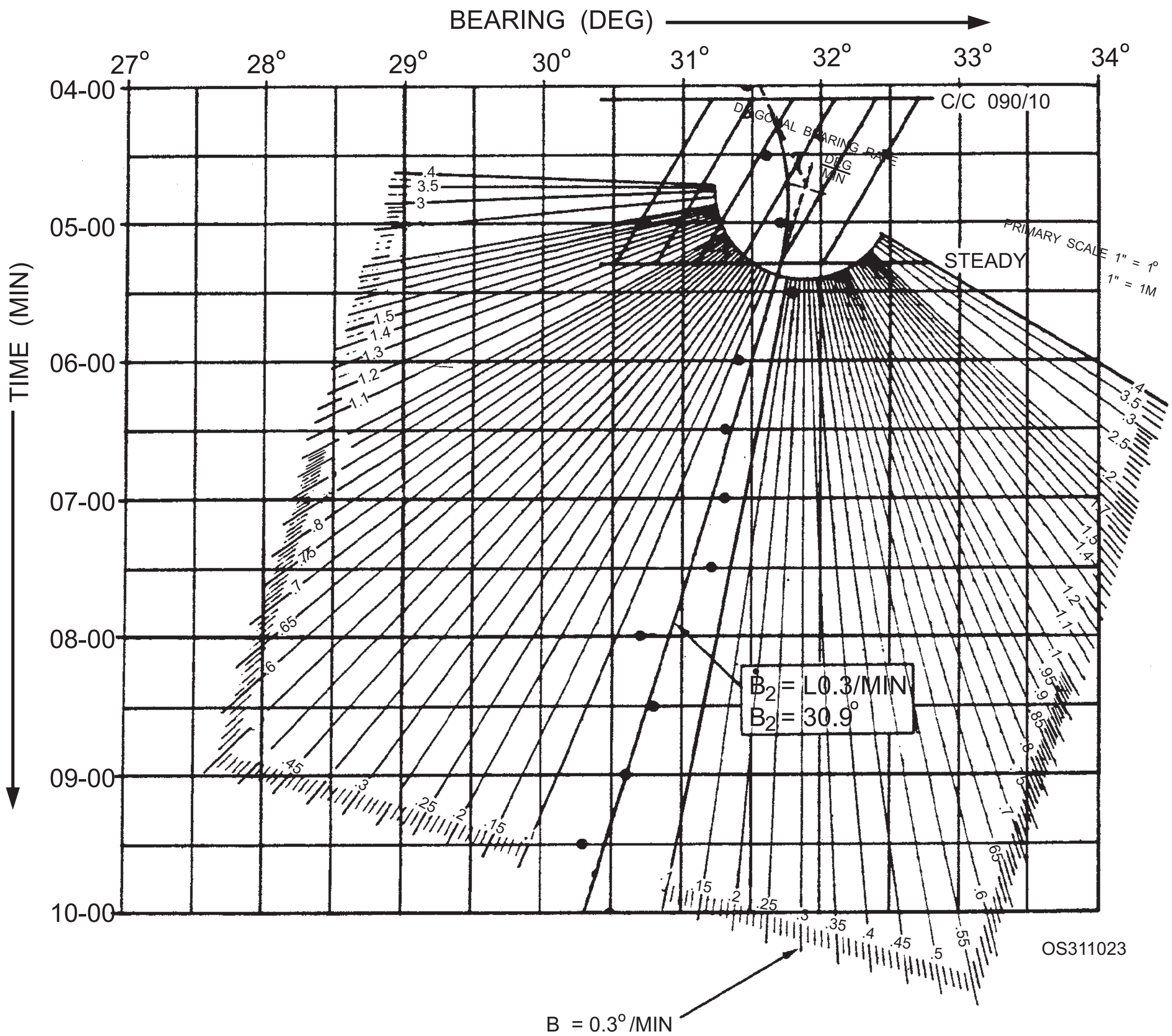

Figure 10-23.—Time/bearing plot after (leg 2) measurement.

Obtain a good time reference consistent with sonar and the time/bearing plot. If you use problem time instead of local time, make a note on the plot, correlating problem time to local time.

After beginning the plot, mark the bug precisely on the plotting interval. Usually this is every minute, but it could be as long as every 2 or 3 minutes, depending on the bearing rate ($\dot{B}$). Note the time beside own ship's position marks on the DRT, using two-digit numbers for minutes.

Use faired bearings ($\overline{B}$) from the time/bearing plot if at all possible. Faired bearings tend to be more accurate than raw sonar bearings. Keep in mind, though, that using faired bearings causes the plot to lag the problem.

With the parallel motion protractor (PMP), plot the faired bearings to the nearest 0.1°. Draw the bearing line well past the maximum expected target range, starting about 1 inch from own ship's position. Mark the time beside the end of the bearing line.

Begin your strip analysis after you plot three or four bearing lines. The ASW evaluator normally establishes a range of assumed target speeds based on a turn count or other estimate. Plan on using a maximum of three speed strips during your analysis. For example, if the estimated speed range is 6 to 11 knots, use the 6-, 8-, and 10-knot strips. Fit each strip across at least three bearings. The line along the edge of the fitted strip represents the target track (course). If, as is usually the case, you cannot make a good fit over the first three lines, try to fit a strip to three of the first four lines.

After you obtain a fit, predict the mark at least two points ahead, as in figure 10-26. The next bearing line may not fall through the predicted point, because of either a bad bearing or a target maneuver. If so, redo the problem using at least one more bearing. Trace a line along the edge of the fitted strip representing the

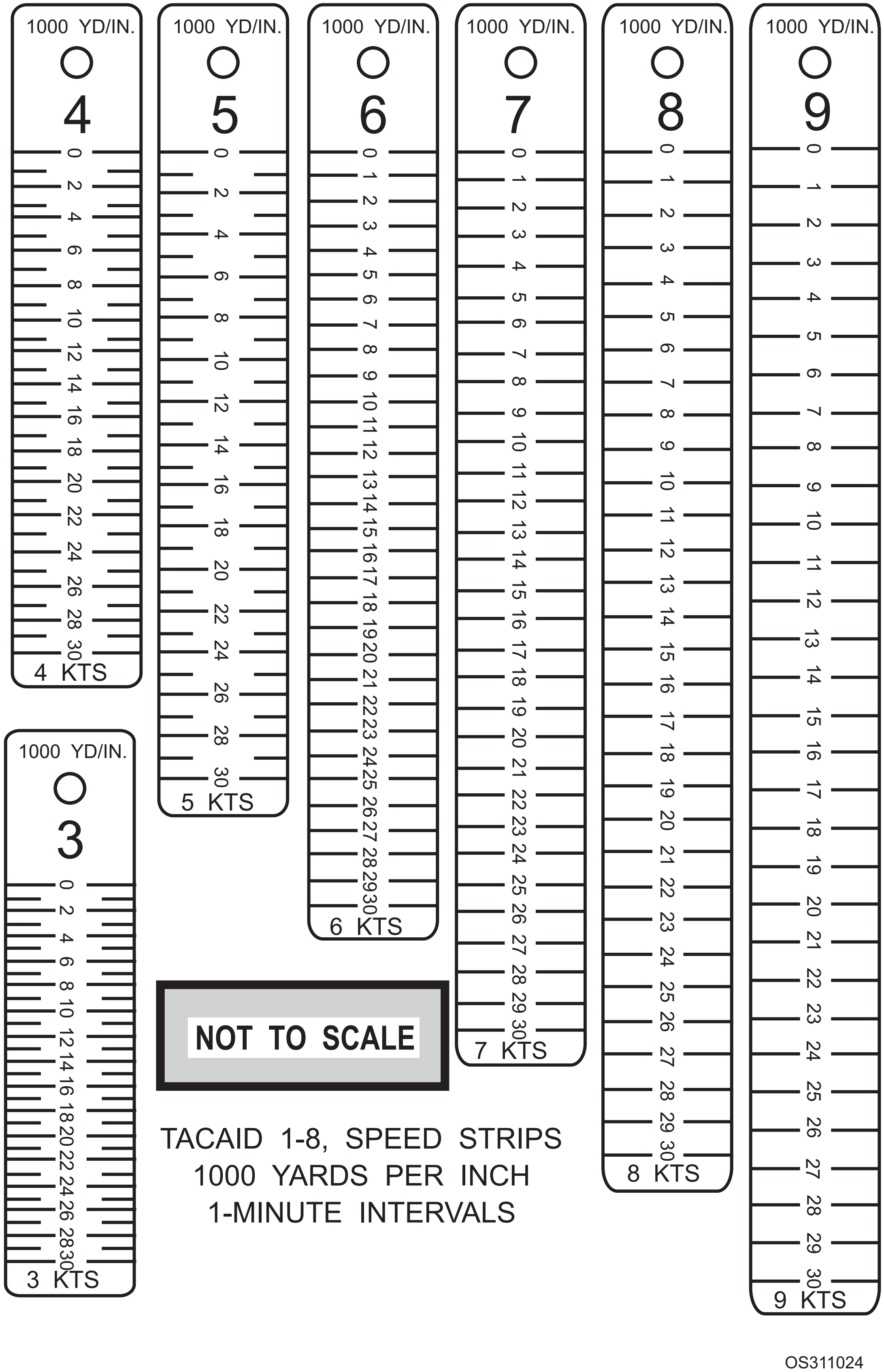

Figure 10-24.—Example of speed strips.

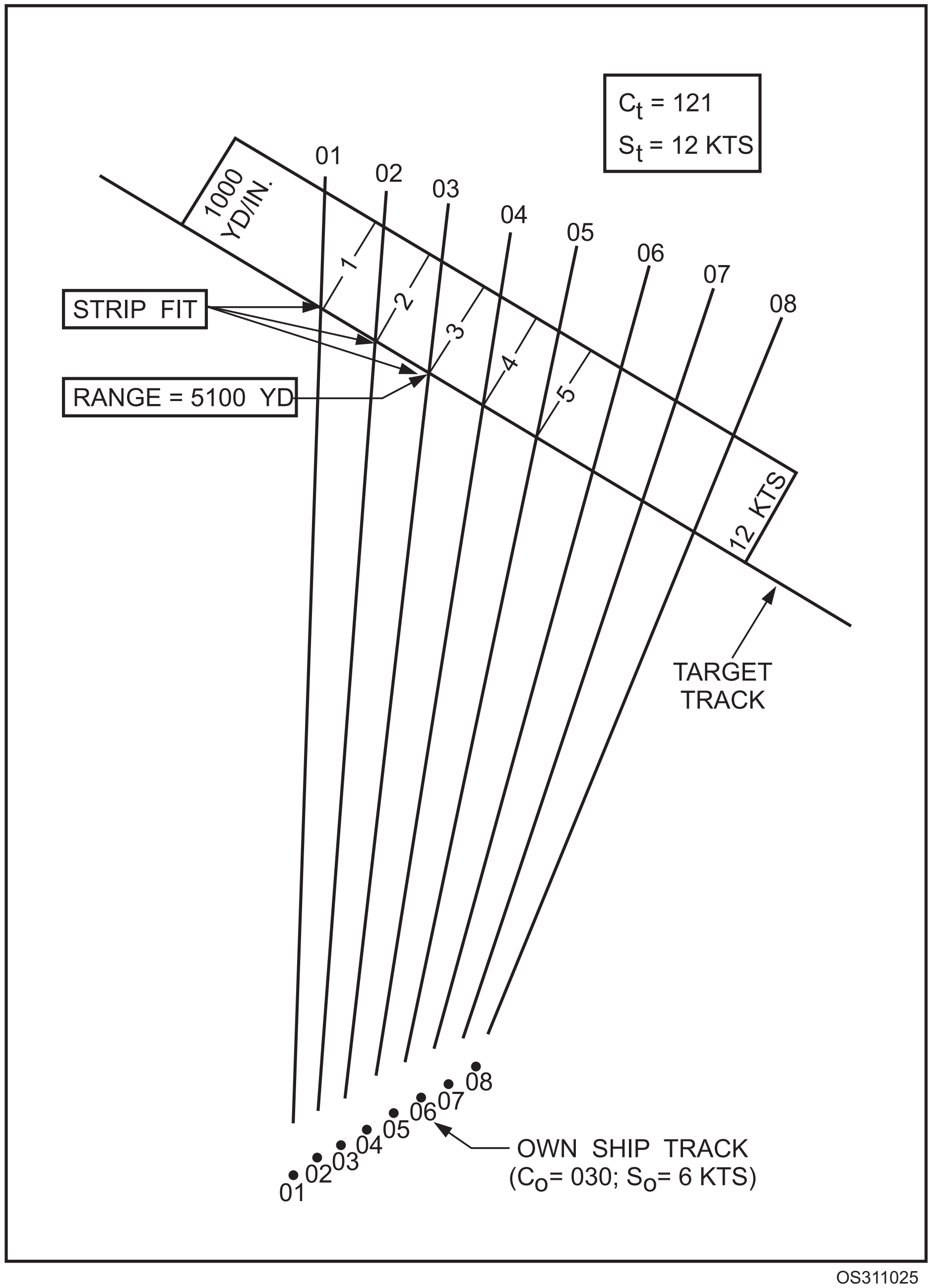

Figure 10-25.—Fitting speed strips.

target's track. Record the target's course and assumed speed in a box near the line.

After an own-ship maneuver, use a different color to plot the bearing lines. If plot information is coming from a towed array, do not collect bearings during a turn, but wait until the array has stabilized after the turn to start again. (For hull mounted arrays, wait until the ship steadies to obtained faired bearings.) Figure 10-27 shows three speed strips fitted prior to an own-ship maneuver. Note that only one strip fits following the maneuver.

The strip plot is most valuable when used in conjunction with other techniques such as DEKE and Ekelund ranging. When more mental analysis weight is given to one technique over another, the quality of information/data and equipment limitations must be kept in mind constantly. The more techniques you can apply, the greater confidence in the range estimate.

Maximum Range for Assumed or Estimated Target Speed

Sonar operators can frequently estimate a target's speed by counting screw beats and using

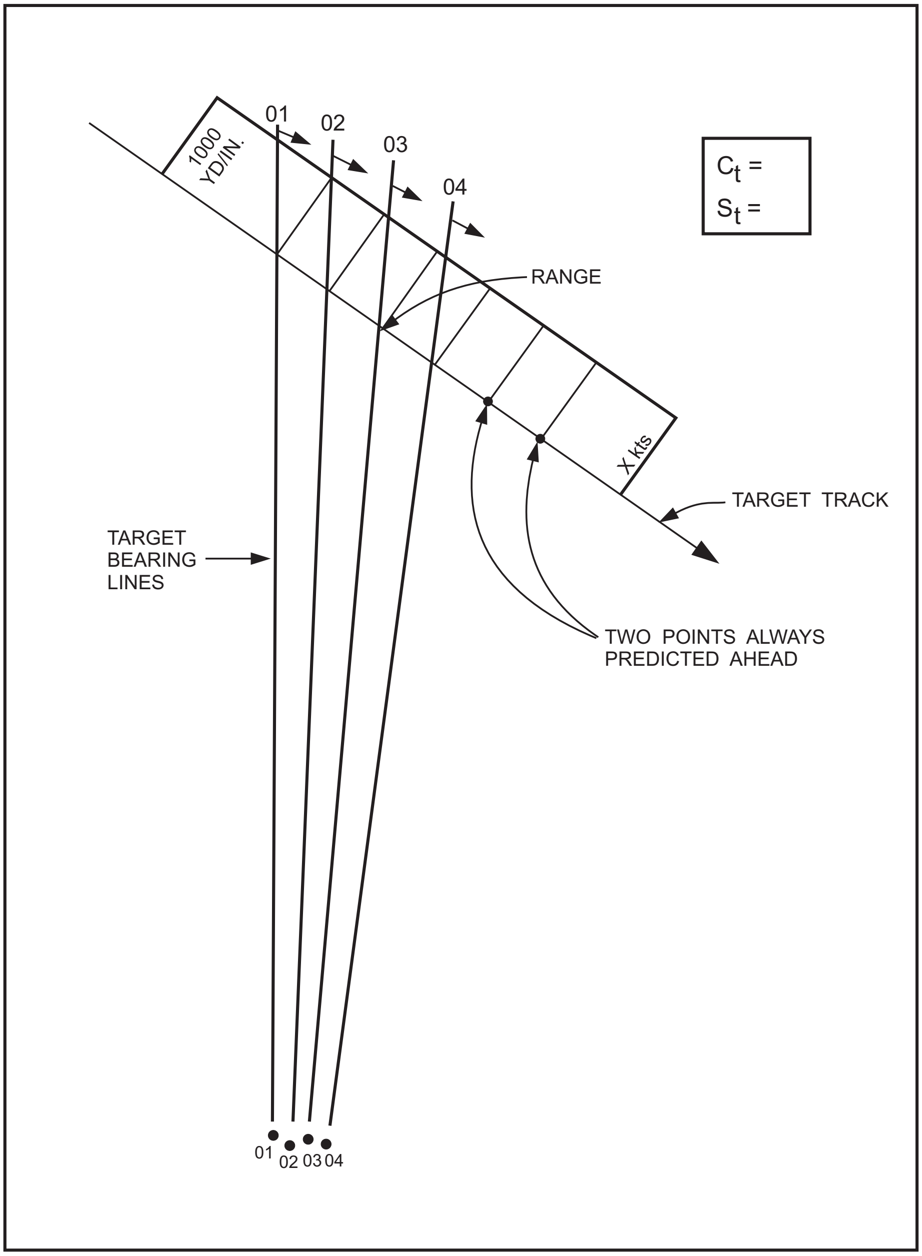

Figure 10-26.—Fitting speed strips with predicted points.

turns-per-knot ratios. You can determine the maximum range for an assumed or estimated speed at any instant by placing the chosen speed strip interval perpendicular to two consecutive bearing lines representing a corresponding interval of target travel. This assumes a 90° target angle; that is, all of the target speed is across the LOS. See figure 10-28.

Minimum Target Speed for a Given Range

You can determine a minimum speed for any given range by finding the speed strip that fits perpendicularly between two bearing lines at the given range. See figure 10-29.

Minimum Range

You can read an absolute minimum range from the strip plot if own ship and the target are moving in opposite directions relative to the line of sound (fig. 10-30). All bearing lines must cross between the target and own ship.

Absolute Maximum Range

You can determine an absolute maximum range when the motion of own ship and the target ship are in the same direction relative to the LOS, and own ship's speed across the LOS is greater than the target ship's

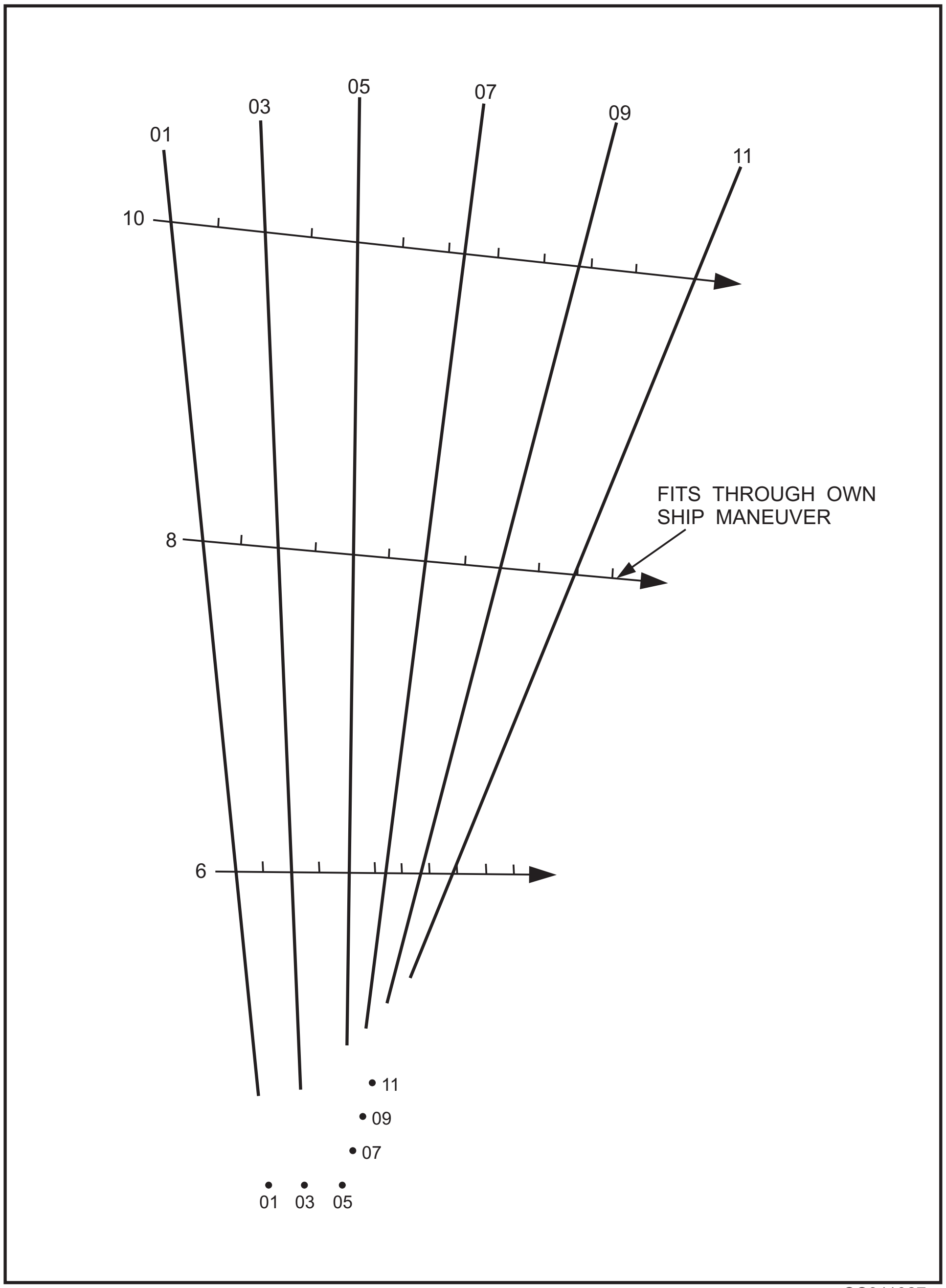

Figure 10-27.—Speed strips fitting through a maneuver.

(fig. 10-31). In this case, all bearing lines must cross at a range greater than that of the target.

General Direction of Target Motion

You can determine the direction of the target's motion if:

1. own ship points at the target (not applicable to towed arrays);
2. own ship's speed is zero or near zero (not applicable to towed arrays); and
3. own ship performs a maneuver when crossed bearings are present.

Situations 1 and 2 are self-explanatory. You can determine situation 3 from an analysis of the strip plot. On a single leg, you cannot determine if the target is beyond or closer than the cross bearings unless you have already determined the target's direction.

Note in figure 10-32 that the cross bearings determine minimum range, because the chronological sequence of bearings continues in the same direction at a greater range. At less than the minimum range, the

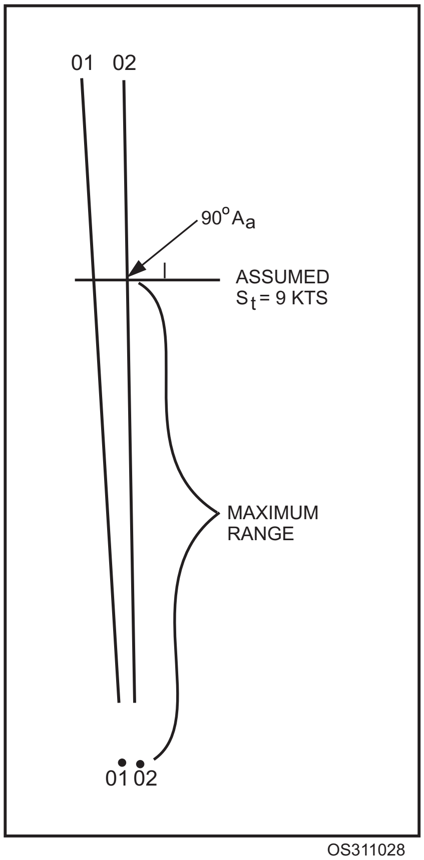

Figure 10-28.—Determining maximum range.

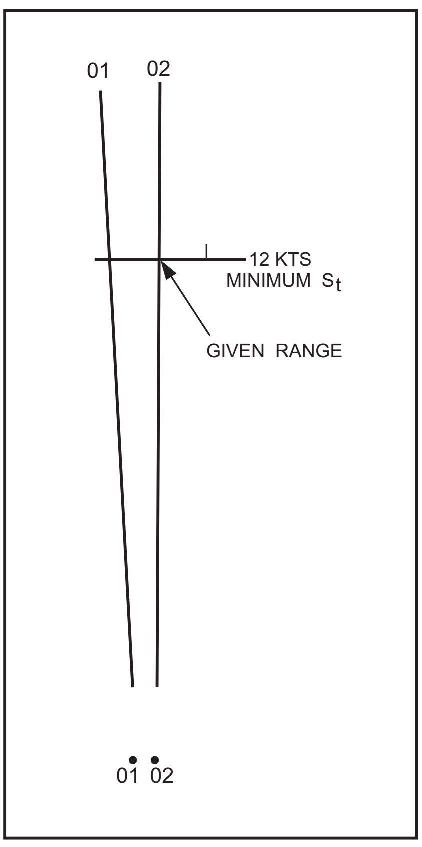

Figure 10-29.—Determining minimum speed.

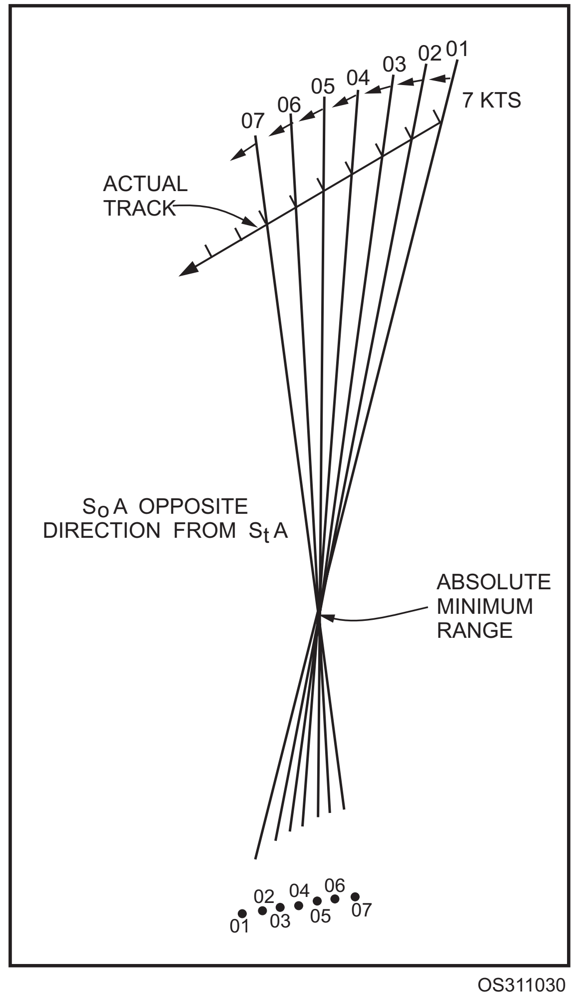

Figure 10-30.—Determining minimum range from cross bearings.

chronological sequence of bearings reverses directions. Unless a target maneuver has occurred, that is impossible. Therefore, the cross bearings indicate minimum range.

Small Target Angle

Figure 10-33 illustrates an example of a situation in which own ship reverses the direction of target motion across the LOS by crossing the target's track. In this circumstance, because the target angle is small, maximum and minimum ranges develop. The chronological sequence of bearings is continuous, not only beyond the first maximum range and inside the last minimum range, but also in between the maximum and minimum ranges. What has occurred in this instance is that target's position has been bracketed. This type of display on the strip plot is characteristic of small target angles.

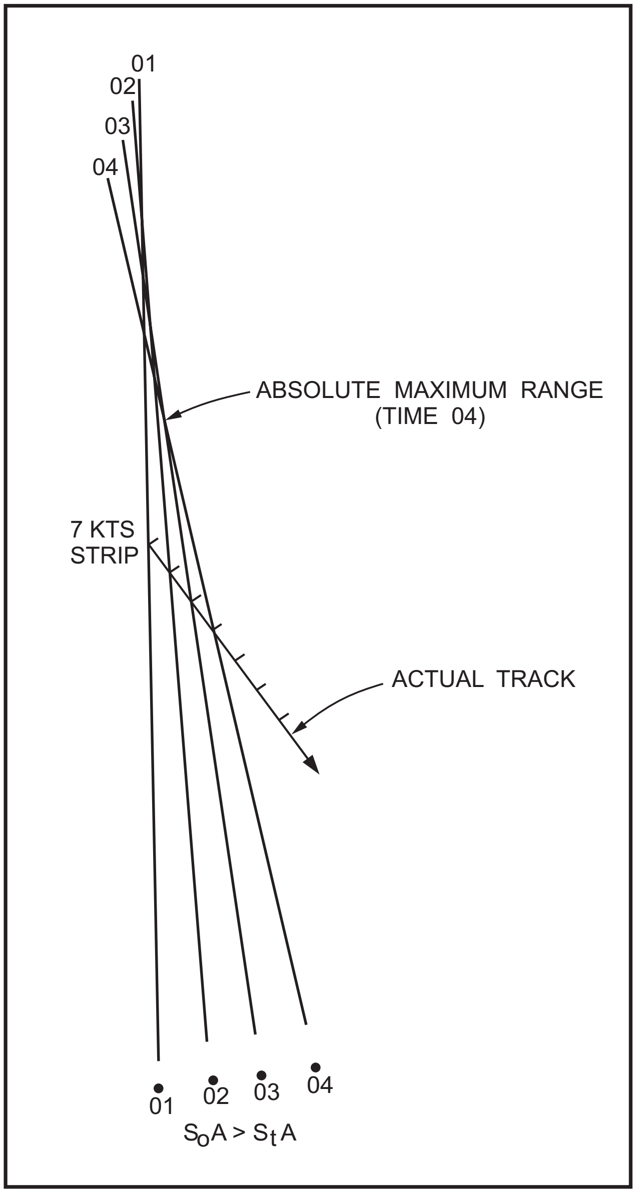

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Figure 10-31.—Determining maximum range from cross bearings.

Detecting an Incorrect Target Speed Estimate

An incorrect target speed estimate can be easily detected on the strip plot after an own-ship maneuver. See figure 10-34. In this hypothetical case, 12 knots is the only speed that fits before and after own-ship's maneuver. For the other speeds used, a range jump occurred at the time of the maneuver. After determining an incorrect speed estimate in this manner, use figure 10-35 to determine whether the actual target speed is above or below the estimated speed according to the direction of the range jump and change in relative speed across the LOS (SA). Repeat this procedure as needed to obtain a best estimate of target speed.

Geographic Plot

The geographic plot is an all-purpose diagram that combines methods suitable for TMA, tracking, and attack. The plot can accommodate raw sporadic sonar bearings from very distant targets as well as continuous information at short range. Active sonar and radar bearing and range data can also be readily plotted and evaluated. The geographic plot is, in short, a device that can integrate and unify all sensor inputs to the combat information center.

The geographic plot can provide useful TMA information throughout an entire operation, from initial detection at long range, through intermediate tracking of both broad and narrow aspect targets, and finally as a post-torpedo launch device. Plot geometries are shown in figure 10-36.

The geographic plot provides a high degree of flexibility when bearing information is shifted from active to silent search or vice versa. The plot will also accommodate the special requirements of towed-array bearing data and provide continuity in tracking as the target is acquired by different ship sensors.

Finally, the geographic plot provides a real-time history of the encounter.

The geographic plot is used in the following situations:

1. Tracking non-maneuvering and maneuvering targets
2. Tracking broad aspect and narrow aspect targets

BROAD ASPECT TARGET—VERIFICATION

When target tracking has proceeded to a stage where the CIC evaluator has developed a reasonable solution from all TMA sources, the evaluator passes this solution to the geographic plot. (Because of manning levels and space limitations, the geographic plot and the strip plot are combined in one plot.) This solution will become a new anchor point.

The Coffey Assumption

The Coffey assumption process for target course solution may also prove valuable during this initial tracking period. The process has two limiting factors

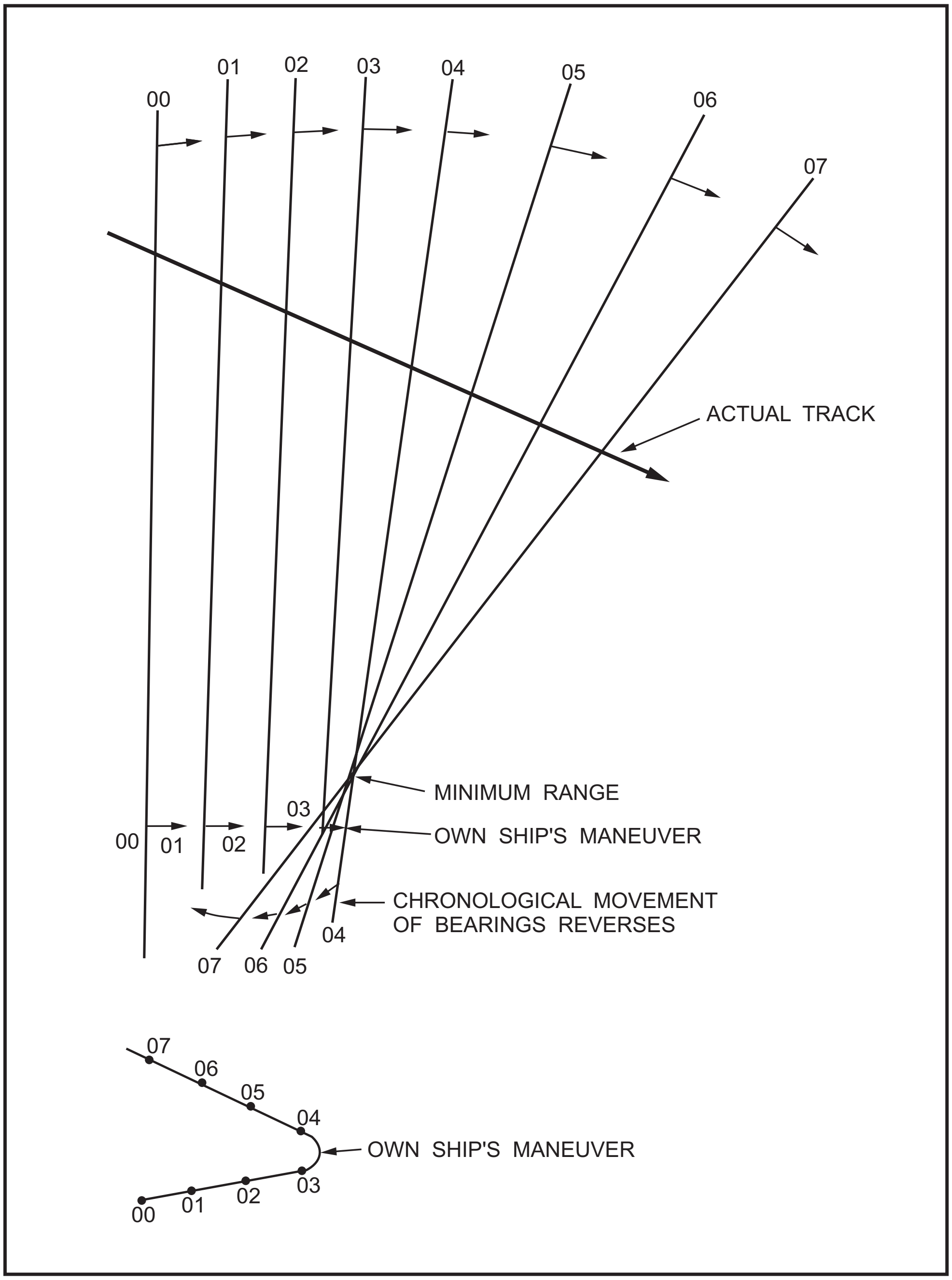

Figure 10-32.—Determining general direction of target motion.

that make it useful in the low-bearing rate, high-range-rate initial contact situations under discussion. First, $\dot{B}$ must be less than 1.5° a minute, and second, S_oA must be less than S_t.

The Coffey assumption is that the bearing rate is zero. Courses for zero-bearing-rate targets (opening and closing) are determined, then course corrections to the zero-bearing-rate courses are determined for the measured bearing rate. The following example refers to figure 10-37. To solve for zero-bearing-rate courses, place own ship's vector at the center of the maneuvering board. In this example, C_o = 060°, S_o = 5 knots, and the target bearing is 010°. If the target had a zero bearing rate, the bearing would remain at 010°. If own ship's course were 010°, the target's opening course would be 010°, and its closing course would be the reciprocal of 010°, or 190°. The target's DRM is drawn from the head of own ship's vector parallel to the 010° bearing line and to the edges of the maneuvering board. To determine target course, a target speed must be assumed. The Coffey assumption zero-bearing-rate courses are at the intersection of the DRM and the target's speed circle. In the example, a

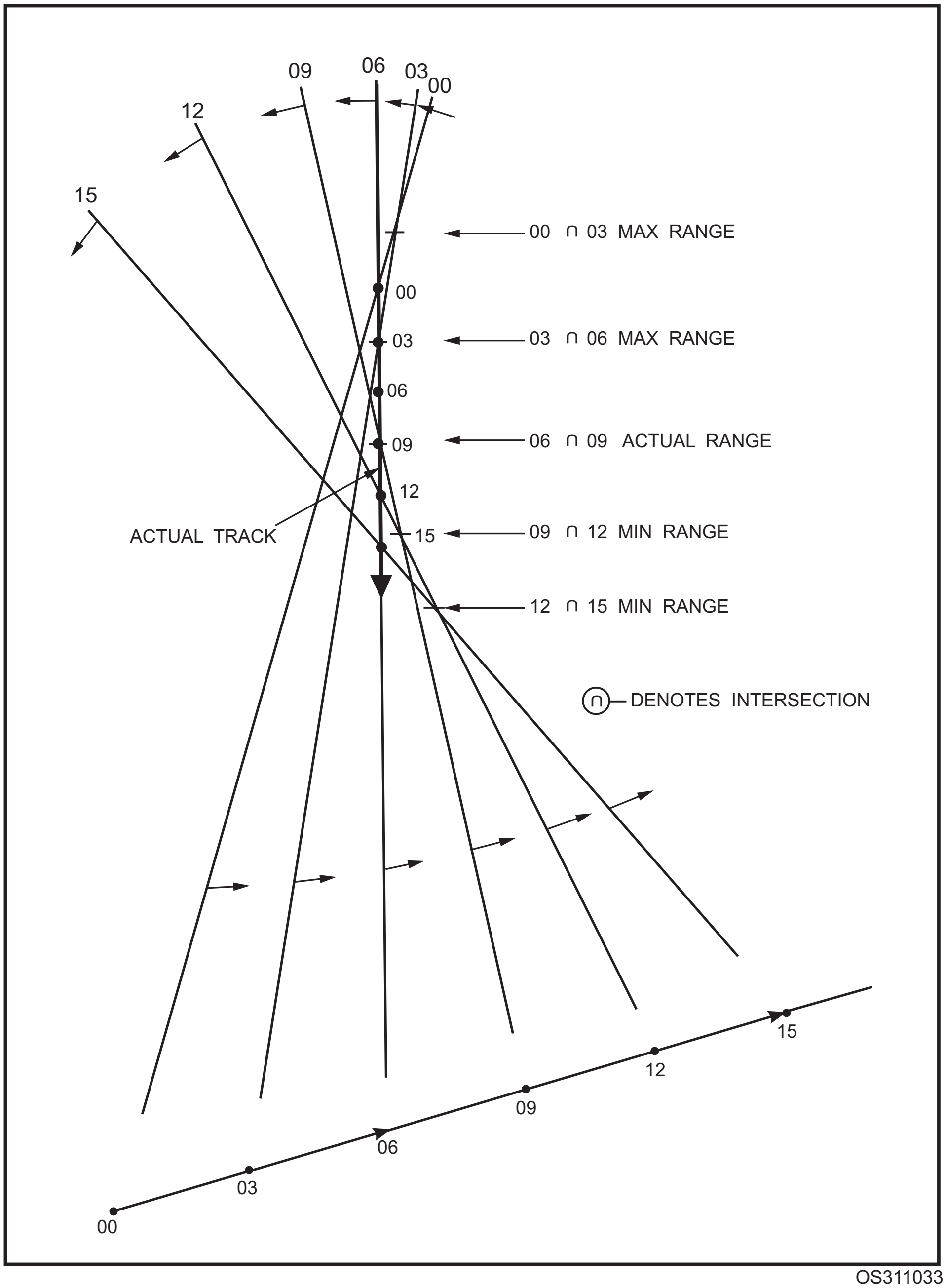

Figure 10-33.—Strip plot for small target aspect.

speed of 10 knots is assumed; therefore, the courses are 032° opening and 167° closing.

You continue the technique by using the measured bearing rate. In this example, assume the bearing rate is left 0.5°/min. Now compute a correction factor. Here, it is 50 x bearing rate. For the problem being computed, the correction is 50 x 0.5 = 25°. Use this factor correcting the zero-bearing-rate courses for measured bearing rate.

To apply the correction factor, divide the maneuvering board into two areas, left and right, with respect to the target's bearing. Then apply the correction to the zero-bearing-rate courses in the direction of the bearing rate. In the example, make the correction of 25° to the left area of the maneuvering board. The resulting target courses are 009° opening and 191° closing. This completes the Coffey assumption technique.

$$\frac{C_t}{\dot{B}} = \frac{X_1}{\dot{B}_1} - \frac{X_2}{\dot{B}_2}$$

Refer to figure 10-38 for construction of the plot for the following problem. Use the course, speed, and target bearing values given under "The Coffey Assumption" heading above as the first leg of the

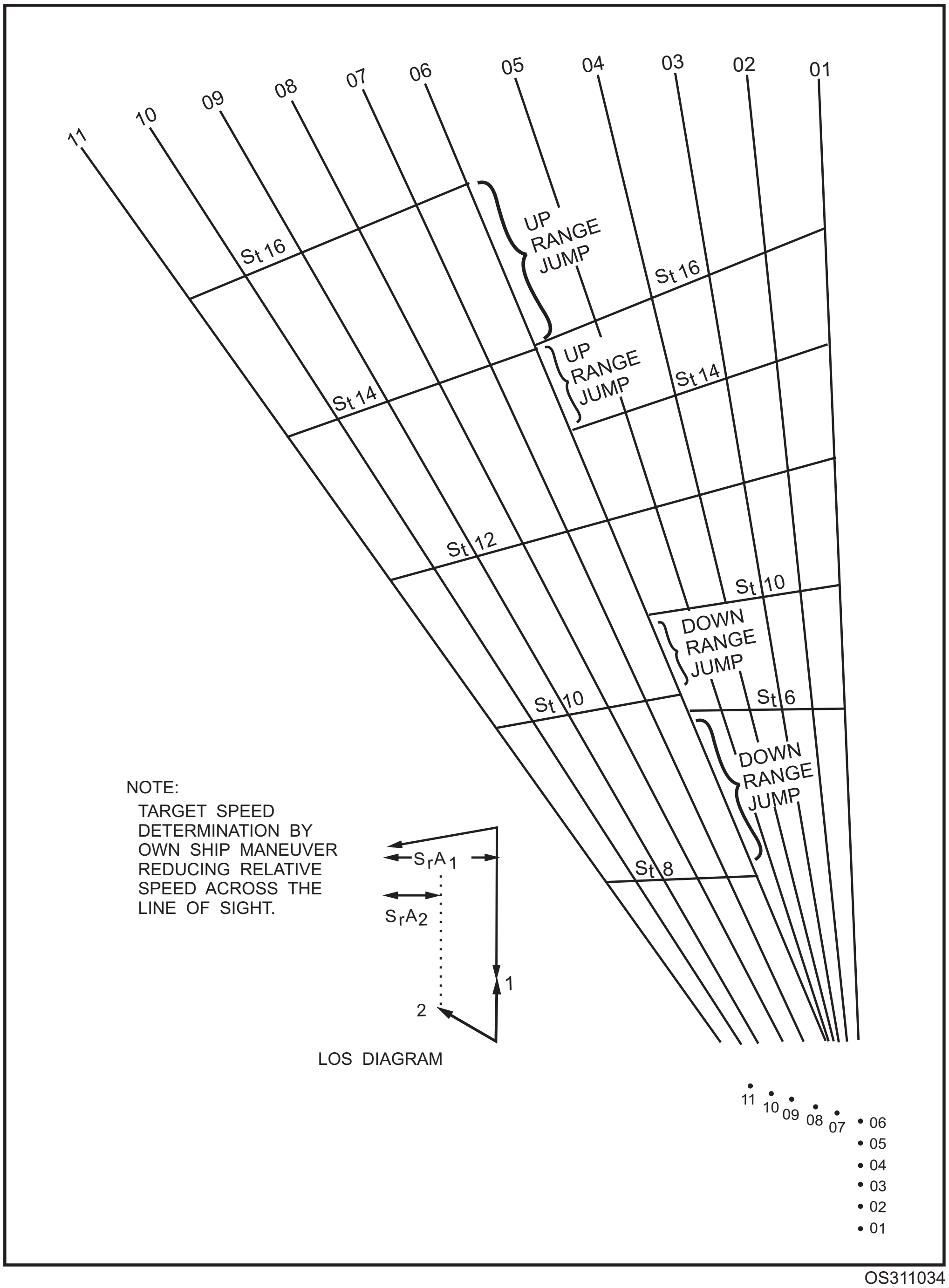

Figure 10-34.—Determining target speed using range jump.

S_rA	UP	DOWN
Decrease	Smaller S_t	Larger S_t
Increase	Larger S_t	Smaller S_t

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Figure 10-35.—Range jump significance.

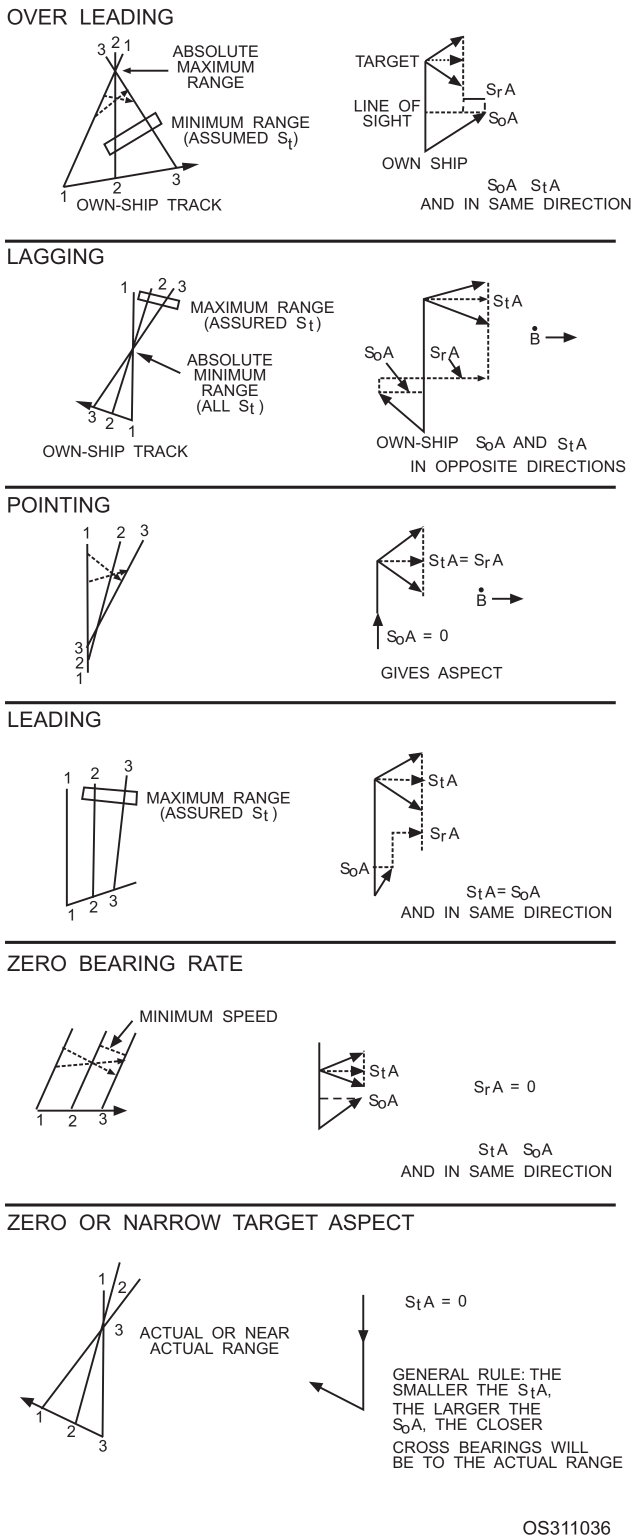

Figure 10-36.—Geograph/LOS plot geometries.

maneuver. Assume that own ship changes course to 300° for the second leg of the maneuver and increases speed to 7 knots. The figure shows the DRM and the zero-bearing-rate course (closing) for the second leg.

The values of interest can be summarized as follows:

VALUE	1st Leg	2nd Leg
C_o	060	300
S_o	5	7
$\dot{B}$	L 0.3	R0.9
B	010	008

Considering only the closing case:

$\dot{B}$ = L 0.3 + R 0.9 = 1.2 (add opposite, subtract same direction)

C_t = 229 - l66 = 63 degrees

Applying these numbers to the equation above, we find

$$\frac{63}{1.2} = \frac{X_1}{0.3} - \frac{X_2}{0.9}$$

Solving the equation produces the following corrections:

$X_1 = 16$

$X_2 = 47$

By looking at the plot, we can see that the application of the correction is obvious. For example, the resulting Coffey solution course (closing) is 182°. This completes the technique for closing course. The same technique is used for opening courses. The Coffey assumed courses and speeds should be updated as the tactical situation progresses and newer information becomes available.

Calculator-assisted Procedure

HP-67/97 programs for computing a relative motion TMA solution are available from the Fleet Mission Program Library (FMPL), Naval Tactical Support Activity (NTSA). The calculator program solves for the relative course and the relative speed numerically, using raw bearing data. It can use data from a single leg along with an estimate of target range, course, or speed to compute a TMA solution, or it can use data from two legs to compute a TMA solution without any additional estimates of TMA parameters.

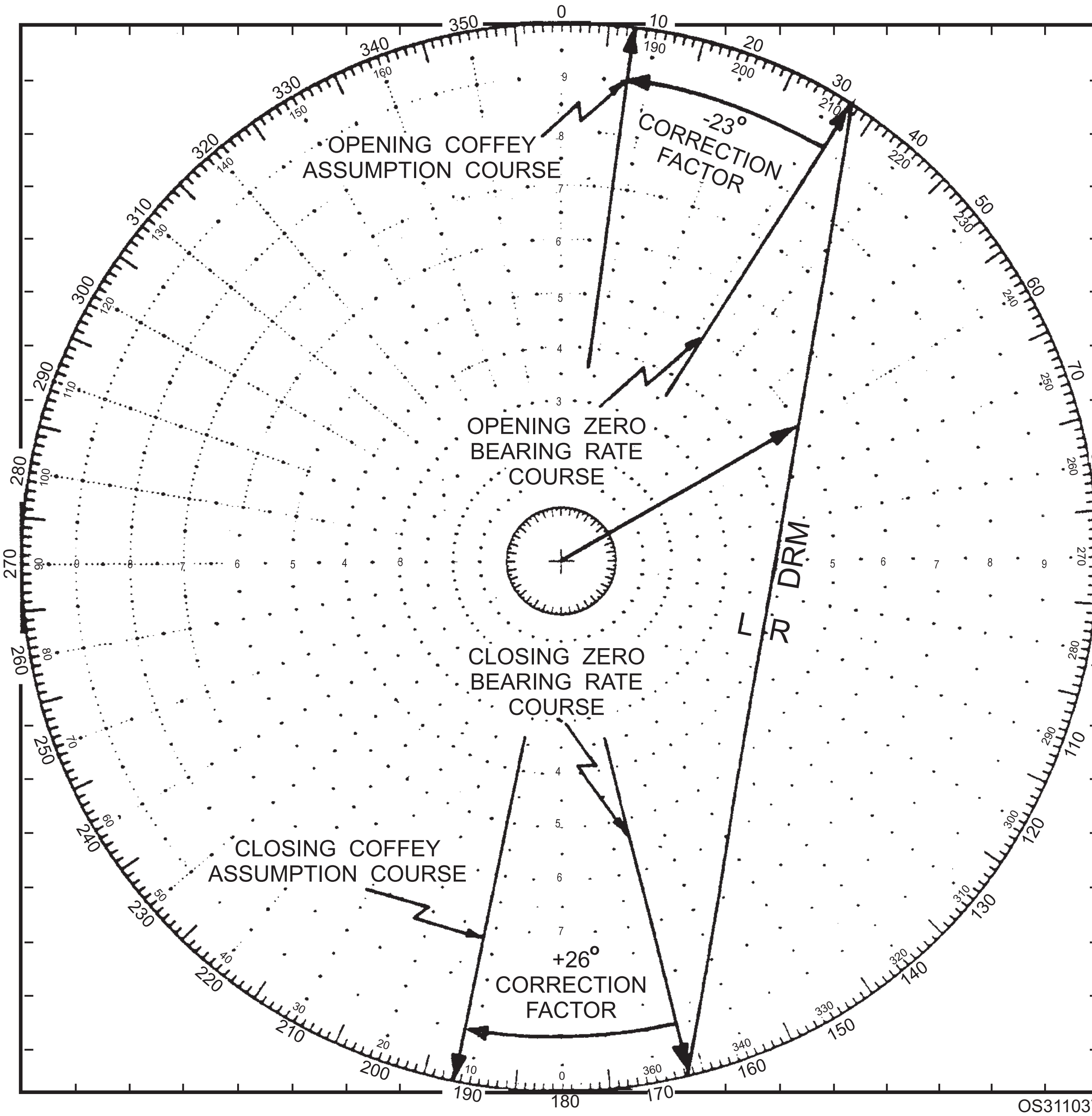

Figure 10-37.—Example of construction of the Coffey assumption.

NOTE

When you use raw data (bearing or frequency) in a calculator to solve for rates, use caution to prevent erroneously biasing the calculated rate by entering a large group of stacked data (bearing or frequency) or an obviously wrong piece of data. You can make this mistake easily when you are concentrating on keying the calculator and not on the quality of data you are entering.

Accuracy

The accuracy of the TMA solution derived from the relative motion plot depends on several factors. Predominant is the accuracy of the bearing information and the assumed target course and speed. The most

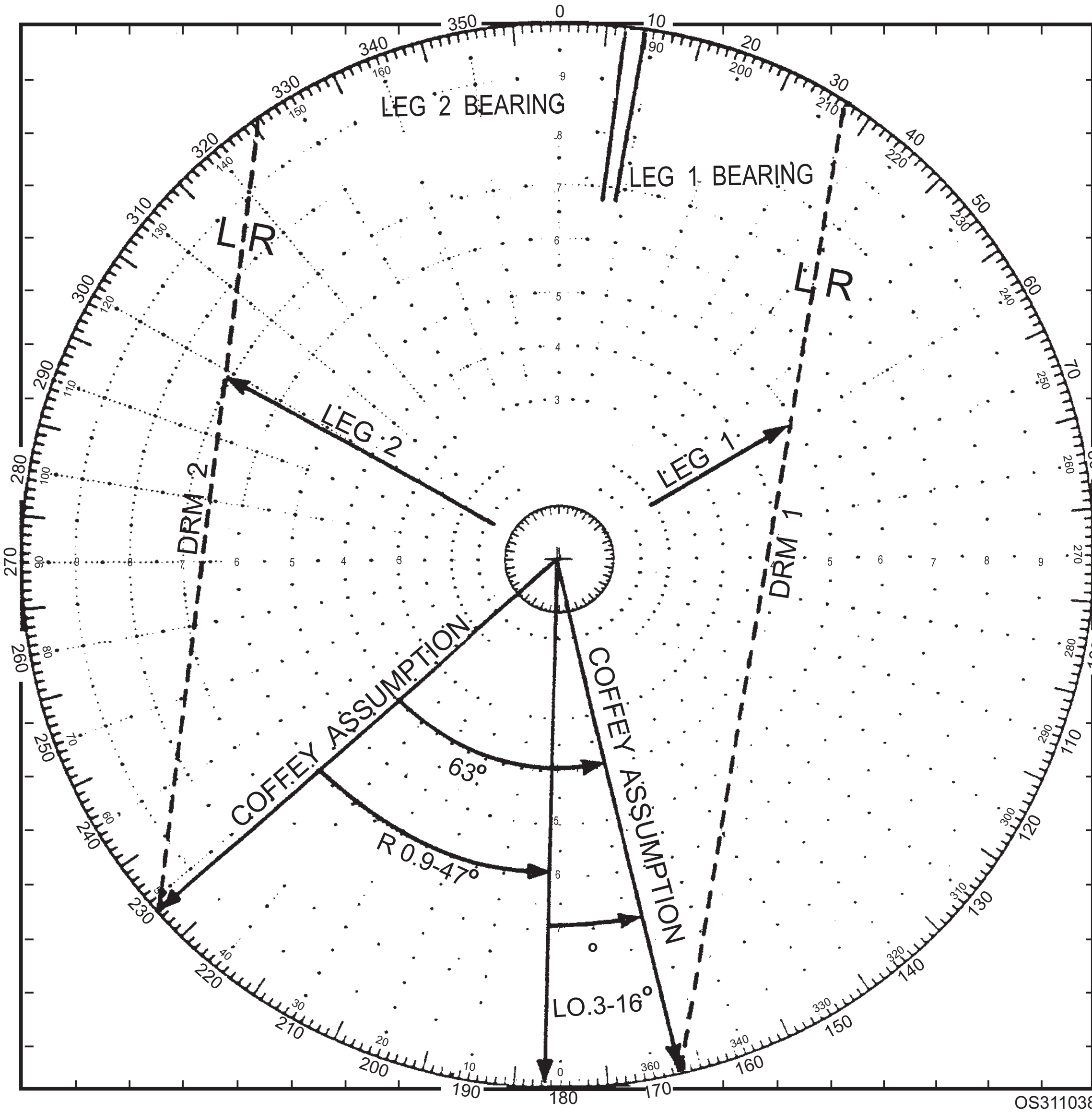

Figure 10-38.—Example of construction of Coffey solution.

accurate solution occurs when the target's speed is greater than own ship's speed.

You can design a smaller bearing-rate scale to increase plotting accuracy at low bearing rates by dividing the existing scale by 10 or by 100. If you do this, the outer scale should read 0.3°/min or 0.03°/min, respectively. Be sure to divide all bearing rates by the same scale factor.

INFORMATION TO THE BRIDGE

Information on new contacts should be passed to the CICWO, who will evaluate it and make recommendations to the OOD on the bridge as a matter of routine. By observing the following suggestions, you will help eliminate the "wait" you might otherwise have to give in response to queries from the OOD.

1. Immediately on detection, pass the range and bearing of all new contacts to the bridge.
2. Give the internal designation or track number.
3. Ascertain the contact's identification, either by a proper IFF/SIF mode response or on the basis of an evaluation of other available information.
4. Give the composition of the contact; for example, single large ship, formation of small ships, or many bogeys.
5. Give an estimate of the contact's true course and speed.

6. Announce a preliminary estimate after three of four plots concerning the point and time of closest approach, followed by more accurate information; also announce whether own ship is on or near a collision course.

7. Furnish an evaluation of the contact by weighing all available information and past movements, determining the contact's future movements and intentions, and recommending an appropriate course of action.

ANSWER TO CHAPTER QUESTIONS

A1. *A bearing that is 180°, plus or minus, from any given bearing.*

A2. *The relative bearing of own ship from a target ship.*

A3. *The geographic plot (also called the navigation plot) shows the true movement of surface, subsurface, and certain air contacts.*

A4. *A formation diagram shows the station of every ship in the formation. It is kept in polar coordinates relative to the formation's axis and center, with formation's center located at the center of the plot. The main body is shown, with each station number and the call sign of the ship occupying that station. Screen sectors are also shown with the call signs of assigned screen units. Sector boundaries are drawn from two groups of four numerals each, specified in a tactical message.*

A5. *Normally, the 20-miles-per-circle scale is used on the air summary plot so that coverage is out to 200 miles.*

A6 . *The tote board contains three sections—bogey, CAP, and other friendlies. It contains all of the amplifying information on every air contact plotted on the air summary plot.*

A7. *The No. 1 (or south) plotter records own ship's contact and, hence, must wear the 61JS phones. The No. 2 (or north) plotter plots the assisting ship and the assisting ship's contact. He or she, therefore, must wear the 21JS phones over one ear and, at the same time, listen to the TG REPT net speaker for the assisting ship's contact reports.*

A8. *Blue; surface friendly symbol.*

A9. *The primary objective of establishing bearing rate is to calculate target course and speed.*

A10. *The time/bearing curve or plot is the keystone to almost all TMA techniques.*

CHAPTER 11

MANEUVERING BOARD

LEARNING OBJECTIVES

After you finish this chapter , you should be able to do the following:

1. Define the basic terminology associated with and explain the layout of the maneuvering board.
2. Solve basic relative motion problems, stationing problems, avoiding course problems, and wind problems.

INTRODUCTION

In CIC, Operations Specialists use a variety of devices—radar, radar repeaters, NTDS consoles, DRT, surface plot, and maneuvering board—to obtain information (course, speed, closest point of approach (CPA), etc.) on all surface contacts within range.

The maneuvering board is used to determine the relative motion between own ship and a contact. Since relative motion is important to the safety of own ship, Operations Specialists must be able to solve every type of maneuvering board problem related to every type of evolution. This chapter deals with a variety of maneuvering board problems, beginning with the very basic information and moving up to more advanced problems.

RELATIVE MOTION

The solution to any maneuvering board problem is fairly simple if you understand the fundamentals of relative motion.

Motion is change of position. All motion is considered relative to some frame of reference. There are two types of references: fixed and moving. A common fixed frame of reference is the Earth. A change of position in relation to the Earth is called *geographical* or *true* motion. An automobile traveling from Baltimore to Philadelphia and a ship steaming from San Francisco to San Diego both exhibit true motion. In both examples the vehicle is moving from one point on the surface of the Earth to another.

The motion of *one object with respect to another object* is called *relative* motion. In relative motion, only the motion (both direction and speed) between the two objects is considered. This means that one of the objects is considered to be at rest *within their frame of reference*. For example, consider two vehicles traveling in the same direction on a highway. Vehicle A has a speed of 65 miles per hour. Vehicle B has a speed of 75 miles per hour. A police officer standing at the side of the highway and checking the speeds of the vehicles with radar would record 65 miles per hour for vehicle A and 75 miles per hour for vehicle B—relative to the Earth. These are the vehicles' *true* speeds. Now assume that you are driving vehicle A. As vehicle B passes you, since it is travelling 10 miles per hour faster than your vehicle, it moves away at a *relative* speed of 10 miles per hour. You have the same sensation of speed between your vehicle and vehicle B that you would have if your vehicle were parked and vehicle B passed you at a *true* speed of 10 miles per hour. When you deal with relative motion, remember that only the motion between the two vehicles matters.

As an Operations Specialist, you must be able to visualize relative motion, because the sweep origin of a PPI scope (own ship's position) is fixed. Thus, the motion you see on the PPI scope when own ship is in motion is relative motion. (You will see true motion on a PPI only when own ship is stationary or when the presentation has an input from the dead-reckoning analyzer.)

A simple CIC problem that emphasizes relative motion is one having two ships on the same course, as shown in figure 11-1. Ship A is on course 270° and making 25 knots. Ship B is 1,000 yards astern making 10 knots and also steering 270°. It is obvious that the range between these two ships will increase as ship A

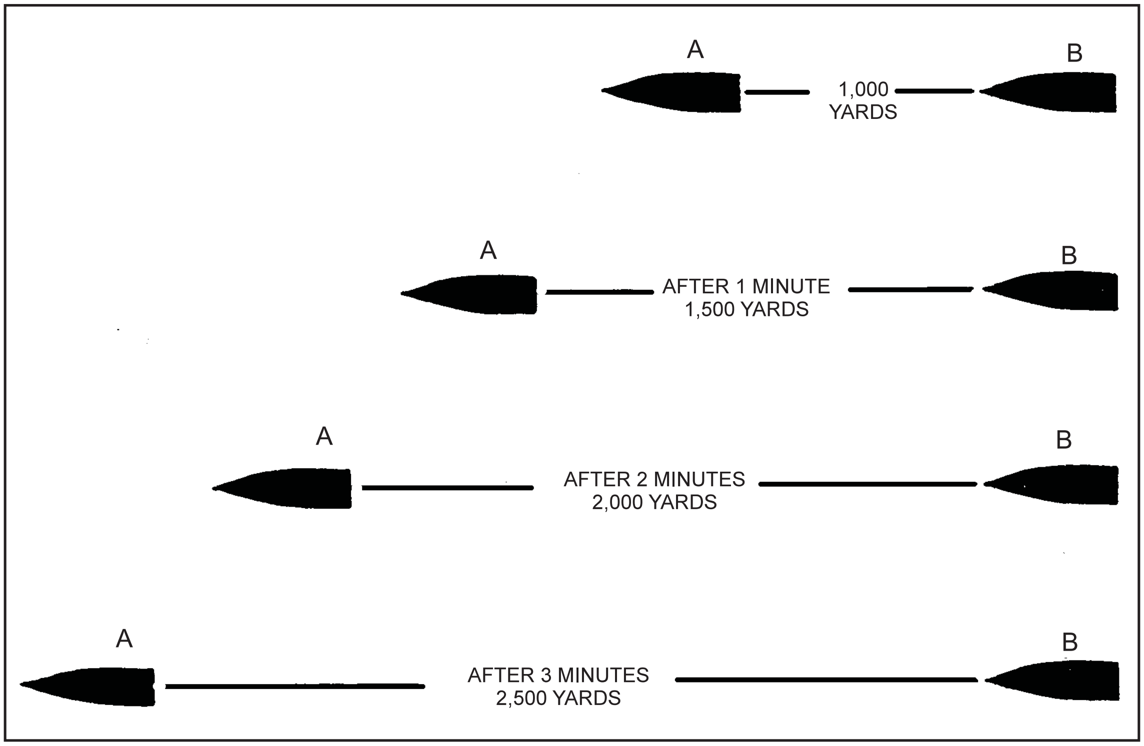

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Figure 11-1.—Relative motion of ship A in relation to ship B. Ship A speed 25 knots. Ship B speed 10 kts.

moves away from ship B. The opening speed is 15 knots, the difference in the speeds of the two ships. Ship A is, then, traveling at a speed of 15 knots, *with relation* to ship B. Relative motion, then, is not concerned with ship A alone or ship B alone, but with the relationship of ship A to ship B.

An observer aboard one ship must judge movement by relating it to that ship. In this example, think about relative motion from the point of view of an observer on ship B. Concentrate on what is happening to the relationship between the two ships—that is, what is happening to the bearing and range of ship A from ship B.

As observed on the PPI scope, A's bearing is always the same (270°), but range is opening constantly at a rate of 15 knots or 500 yards per minute. Stated more precisely, the direction of relative motion is 270° and speed of relative motion (SRM) is 15 knots. Although ship A has a true speed of 25 knots, it is making only 15 knots in relation to ship B.

Now let's consider a situation with two ships on different courses and speeds. Two ships get underway from the same anchorage at the same time (fig. 11-2); ship C is on course 180°, speed 15 knots; and ship D is on course 090°, speed 20 knots.

If you were the surface search radar operator aboard ship C, you would observe ship D moving out from the center of the scope, in a northeasterly direction. See figure 11-3. After an hour, with the ships maintaining their original courses and speeds, ship D would be located at 053°, 25 nautical miles from ship C.

The speed of relative motion (SRM) between these two ships then, must be 25 knots; and the direction of relative motion (DRM), in relation to ship C, is 053°.

You can figure the solutions to these simple problems in your head. However, most relative motion problems are more complicated and require you to use a maneuvering board.

Q1. What is the definition of relative motion?

THE MANEUVERING BOARD

The maneuvering board is a polar-coordinate plotting sheet devised to solve relative motion problems. See figure 11-4. It contains ten equally spaced circles and thirty-six radial bearing lines, one every 10°, originating at the center. At the bottom is a nomogram, which is used to compute speed, distance, and time. On each side of the sheet are two vertical scales, known as *speed/distance scales*.

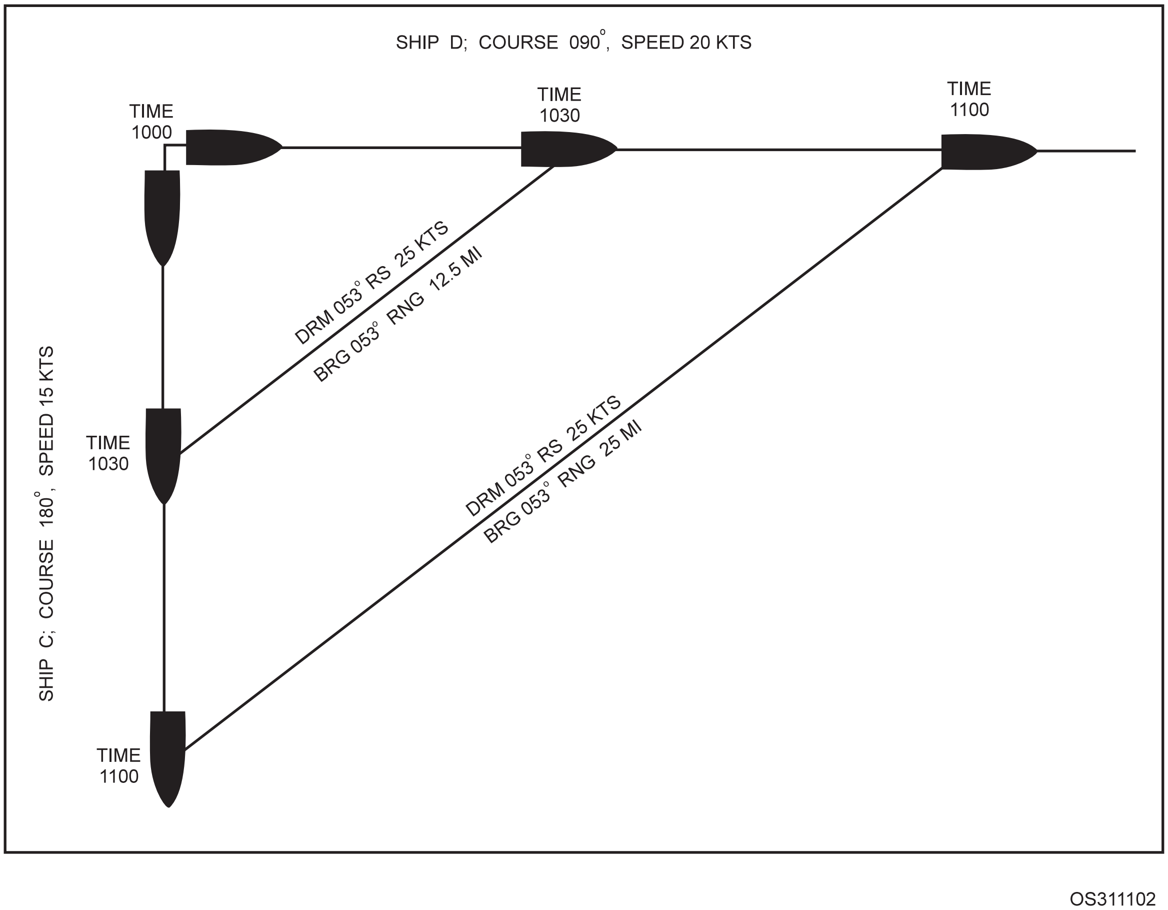

Figure 11-2.—Relative motion between two ships.

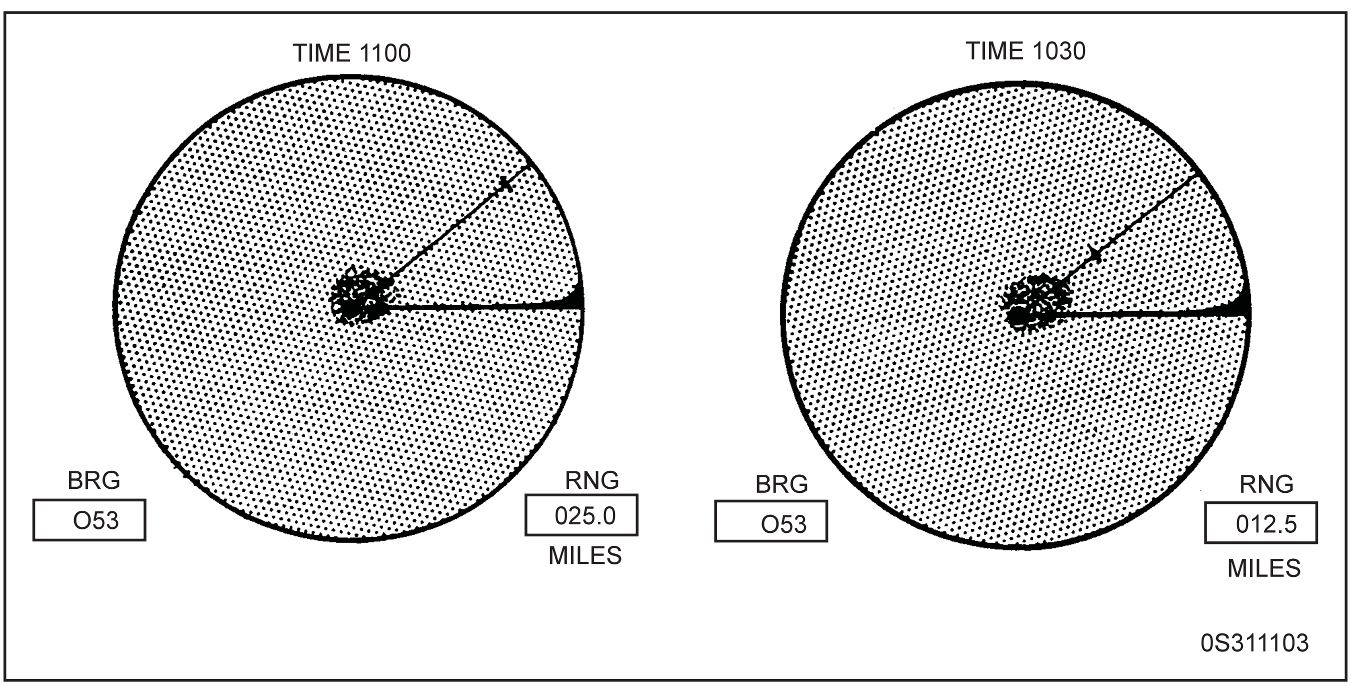

Figure 11-3.—PPI presentation observed on ship C.

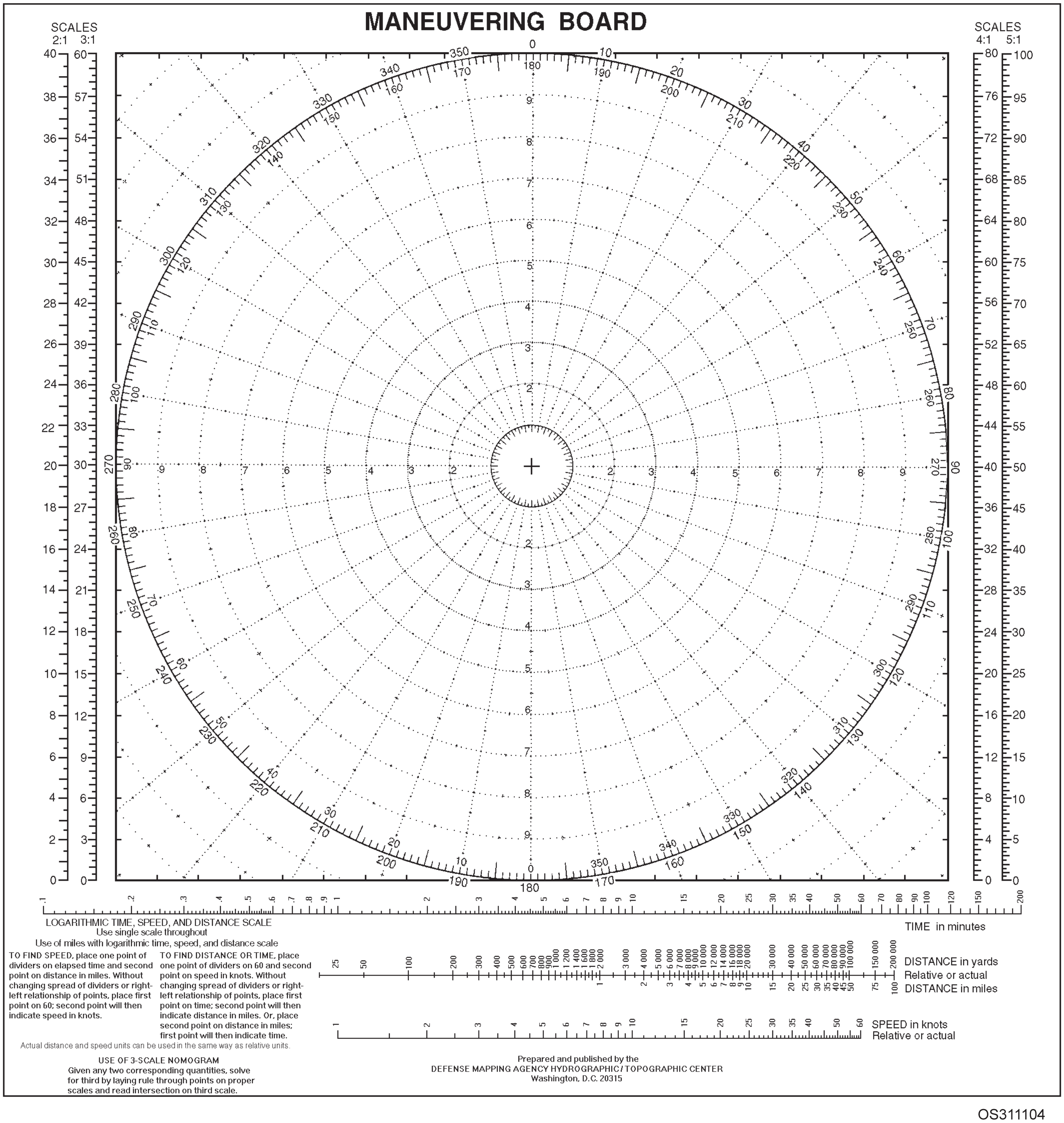

Figure 11-4.—Maneuvering board.

To work maneuvering board problems, you need two additional pieces of equipment:

1. Dividers, for accurate measurements of time, distance, and speed
2. Parallel rulers, to accurately parallel lines of motion

Before you begin working maneuvering board problems, you must understand vectors and the vector diagram as they are used in maneuvering board problems.

VECTORS

We often use the terms *speed* and *velocity* interchangeably, and sometimes we are justified in doing so. However, speed is not always the same thing as velocity. Strictly speaking, speed measures the rate

of travel, while velocity involves not only speed but also direction. Velocity then, is the time rate of motion in a specified direction.

Velocity can be expressed in the form of a vector. A vector is a quantity having both magnitude and direction and is represented graphically by an arrow. In maneuvering board problems, the direction of the vector arrow is used to indicate a ship's course. The length of this same arrow is used to represent the ship's speed. As you plot two or more vectors during a maneuvering board problem, you will be performing a process called "vector addition and subtraction". This process can become somewhat involved, so rather than explain the concept of vector addition and subtraction in detail, we will simply teach you how to plot the vectors and interpret the results. The important point for you to remember is to plot your vectors very carefully, so your results will be accurate.

RELATIVE PLOT

In solving any relative movement problem on a maneuvering board, you must assume one of the moving ships to remain at the center of the relative plot. Therefore, your first consideration is which of the moving ships to place in the center. This ship can be either own ship or another ship upon which ranges and bearings are being taken.

There are advantages to plotting own ship in the center. For example, placing own ship in the center shows the same picture as the one shown on a PPI scope, and any errors in the solution are readily apparent on the scope.

In certain types of problems, such as change-of-station problems, you may find it more convenient to place the formation guide in the center of the maneuvering board.

Regardless of the method you use, refer to the ship you place in the center of the maneuvering board as the reference ship and label it R. Refer to the ship whose movements are being considered in relation to the reference ship as the maneuvering ship and label it M. At the start of a maneuver label the position of M as "M_1" Label its plotted position at the end of the maneuver as "M_2". When you need to plot more than two positions of the maneuvering ship to solve a problem, label them M_1, M_2 , M_3, etc., in consecutive order.

The direction of the line joining the plots from M to M represents the direction in which the maneuvering ship (M) is moving with respect to the reference ship (R). See figure 11-5. This direction is called the Direction of Relative Motion (DRM) and is expressed as a true bearing. Remember, this is not a true movement, but rather the relative movement, which is the result of combining the reference ship's course and speed and the maneuvering ship's course and speed, making the maneuvering ship travel down the DRM line.

The distance between the positions M_1 and M_2, measured to the same scale used to plot M_1 and M_2, is the distance M traveled with respect to R. This is called relative distance. Again, remember that this is not a true distance; it is the relative distance, which is the result of the reference ship's course and speed and the maneuvering ship's course and speed. Relative distance, then, is the measurement of the distance between M_1 and M_2 . Be sure to use the same scale for this measurement as you used to plot M_1 M_2. After you determine the distance between M_1 and M_2 and the time between the plots, you can determine M's *relative* speed. Relative speed is the speed at which the maneuvering ship is moving in relation to the reference ship.

You can solve for relative speed by using the nomogram at the bottom of the maneuvering board. In fact, if you know any two of time, distance, and speed, you can quickly determine the third by using either the nomogram or the logarithmic scale. We will explain how to use the nomogram and the logarithmic scale later in this chapter.

Now, consider the following definitions. You will use them whenever you solve a maneuvering board problem:

1. *Direction of relative motion (DRM)* — This is the direction the maneuvering ship (M) moves in relation to the reference ship (R).
2. *Relative distance (RD)* — This is the distance the maneuvering ship moves with respect to the reference ship in a given period of time.
3. *Speed of relative motion (SRM)* — This is the speed at which the maneuvering ship moves in relation to the reference ship.
4. *Line of relative motion (LRM)* — This is the line that starts at M_1 and extends through M_2 , M_3, and so forth.

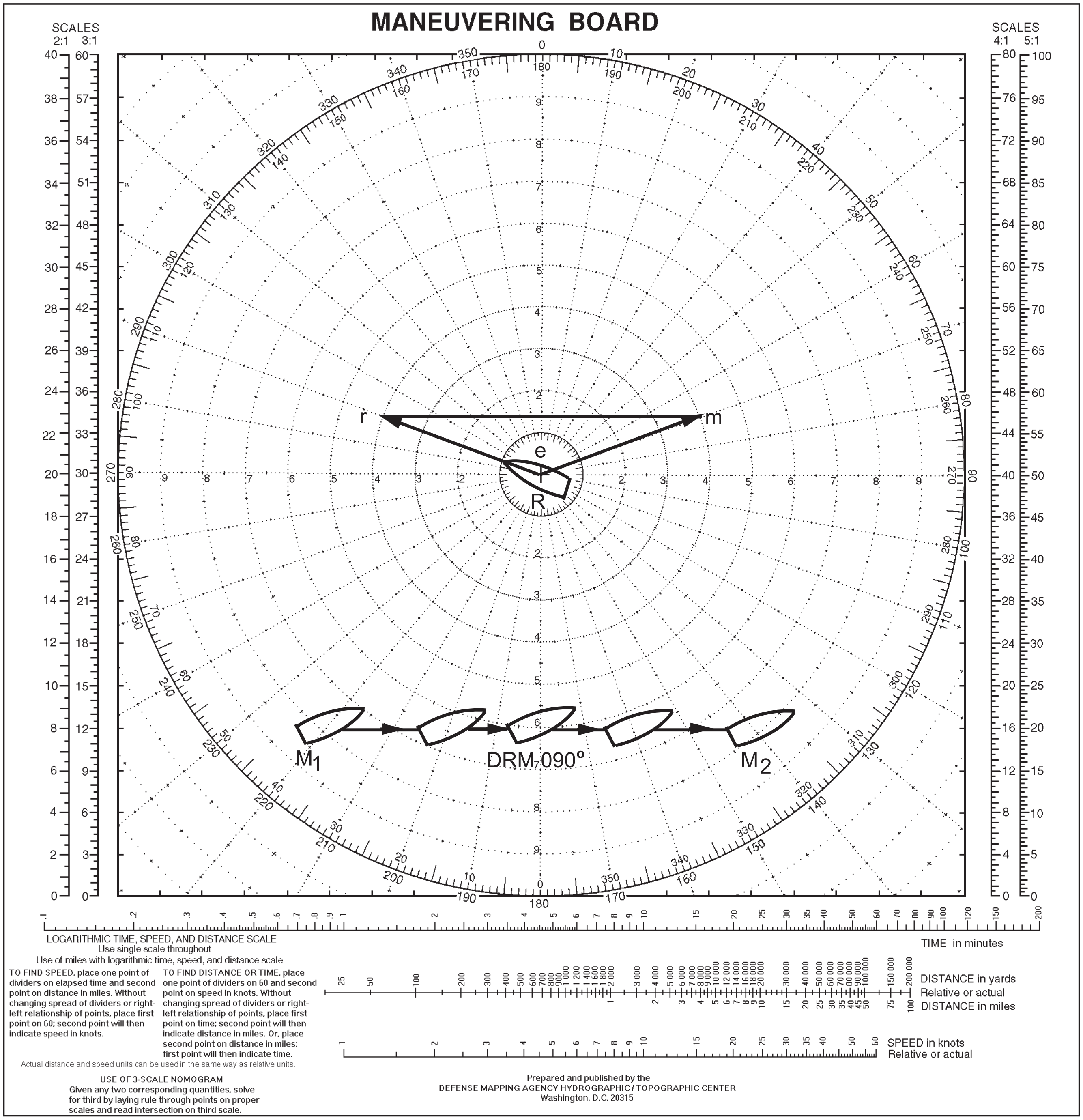

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Figure 11-5.—Relative motion of M with respect to R.

VECTOR DIAGRAM

The true course and speed of each ship is represented on the maneuvering board by a vector drawn outward from the center. The direction of each line corresponds to the course of the ship it represents, while the length of each line corresponds to the ship's speed, plotted on some convenient scale. Standard labels for vectors are used in all maneuvering board problems. Figure 11-5 shows the basic vectors and their labels. The vector *er* represents the true course and speed of the reference ship. The vector *em* represents the course and speed of the maneuvering ship. The vector *rm* represents the relative course and speed of M with respect to R

Relative vectors, such as the *rm* vector, originate outside the center of the maneuvering board. Thus, in

maneuvering board problems, true vectors always originate at the center, and relative vectors always originate outside the center.

Note that since the $M_1 M_2$ vector and the *rm* vector both indicate direction of relative motion, $M_1 M_2$ and *rm* must be parallel and, in every case, drawn in the same direction.

NOTE

To complete the following maneuvering board problems, you must have a few maneuvering board sheets, a set of dividers, parallel rulers, and a pencil. We will explain the mechanics as we proceed through the problems.

HOW TO USE THE MANEUVERING BOARD SCALES

The maneuvering board contains three types of scales: bearing scales, speed/distance scales, and the nomogram. The bearing scale consists of two sets of numbers printed along the maneuvering board's outer circle. The large, outer numbers are true bearings; the small, inner numbers are reciprocal bearings. For example, the reciprocal of 030° is 210°.

The speed/distance scales are provided for you to use when you need to expand the scale of the maneuvering board. The basic circular area of the maneuvering board is based on a 1:1 scale, with the outer circle representing a distance of 10,000 yards. If you need to plot a distance greater than 10,000 yards, use the appropriate time/distance scale to take your distance measurements and expand the distance to the outer ring according to the speed/distance scale you use. For example, if you use the 2:1 scale, convert the outer circle to 20,000 yards (10,000 multiplied by 2). If you use the 5:1 scale, convert the outer circle to 50,000 yards. By expanding the overall scale, you can have the distance between circles on the maneuvering board represent 1,000, 2,000, 3,000, 4,000, or 5,000 yards.

You can also use the speed/distance scales to measure speeds in the vector diagram. On the basic plot, the outer circle represents 10 knots, with each circle representing 1 knot. When you use speed/distance scales, the outer circle represents 20, 30, 40, or 50 knots; with each circle representing 2, 3, 4, or 5 knots (depending on which scale you chose).

The surface search radar will often detect more than one contact at any given time. You can't expect all of these targets to be the same distance from your ship or to have the same speed. To plot this variety of targets, you might be tempted to use a different maneuvering board for each contact. An acceptable alternate to using several maneuvering boards is to do all contact solutions on the same board, using a 5:1 scale for both distance and speed. This scale is compatible with the maximum speed of most ships and with the range scale used by the surface search operator. During tactical maneuvers and other times when greater accuracy is needed, you may select the scale that fits the specific problem.

You may also find it convenient to choose one scale for the relative plot (distances) and another for the vector diagram (speeds). We will discuss how to do this later in the chapter.

At the bottom of the maneuvering board is a nomogram (a set of three interrelated scales). The nomogram provides you a quick way to convert time and speed to distance, time and distance to speed, and speed and distance to time.

Figure 11-6 illustrates time-speed-distance scales. All three scales are logarithmic scales. The top line is a time line, in minutes. The middle line is the distance scale (numbers on top of the distance scale give distance in yards; those below, distance in miles). The bottom line is the speed scale, in knots.

In our discussions concerning the speed and distance scales, we use the words *relative* and *actual.* We do this only to inform you that you may solve both

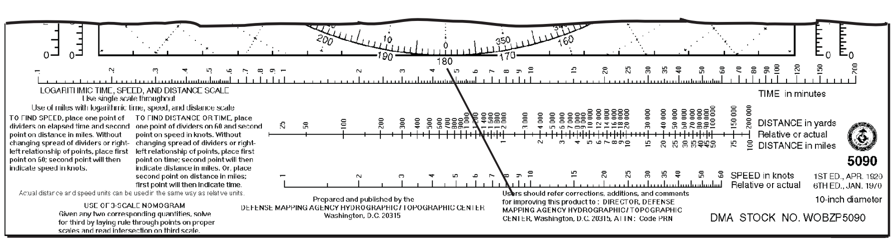

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Figure 11-6.—Maneuvering board nomogram.

relative and actual problems. When you solve a problem, be sure to use the same type of speed and distance. For example, if you use relative distance, be sure to use relative speed.

Time-speed-distance scales are based on the formula “Distance = Speed x Time”. They are so arranged that by marking off any two known values and laying a straightedge through the two points, you can determine the correct value of the third quantity, which is the point of intersection on the third scale.

Suppose a ship travels 1500 yards in 5 minutes. What is the speed? Figure 11-6 shows the graphic solution to the problem. Time is marked at 5 minutes on the time scale. Distance is marked at 1500 yards on the distance scale. A straight line drawn through these two points and extended across the speed scale intersects the speed scale at 9 knots, answering the problem. If the distance in figure 11-6 is relative, then speed (9 knots) obtained is also relative.

Logarithmic Scale

You actually need only one of the three nonogram scales to solve for time, speed, or distance if you know any two of the three values. But since the upper scale is larger, it will provide greater accuracy.

If you use a single logarithmic scale to solve the basic equation with speed in *knots* and distance in *miles* or thousands of *yards*, you must incorporate either 60 (for miles) or 30 (for yards) into the basic equation for the result to have the proper units. We explain this procedure below.

Figure 11-7 shows how to use the upper scale for finding the speed, in knots, when you know the time in minutes and the distance in miles. In this problem, the time is 10 minutes and the distance is 2 miles. Set one point of a pair of dividers at “10” (the time in minutes) and the second point at “2” (the distance in miles). Without changing the spread of the dividers or the right-left relationship, set the first point at “60”. The second point will indicate the speed in knots (12). If you know the speed and time, place one point at 60 and the second point at the speed in knots (12). Without changing the spread of the dividers or the right-left relationship, place the first point at the time in minutes (10). The second point then will indicate the distance in miles (2).

If the distance you use is in thousands of yards, set a divider point at “30” rather than at “60”. If the speed is less than 30 knots, the distance in thousands of yards will always be less than the time in minutes. If the speed is in excess of 30 knots, the distance in thousands of yards will always be greater than the time in minutes.

CLOSEST POINT OF APPROACH PROBLEMS

When range, bearing, and composition of a radar contact are relayed to the bridge, the OOD expects amplifying information shortly afterward about the contact’s course, speed, and closest point of approach.

The closest point of approach (CPA) is the position of a contact when it reaches its minimum range to own ship. This point is at the intersection of a line from own

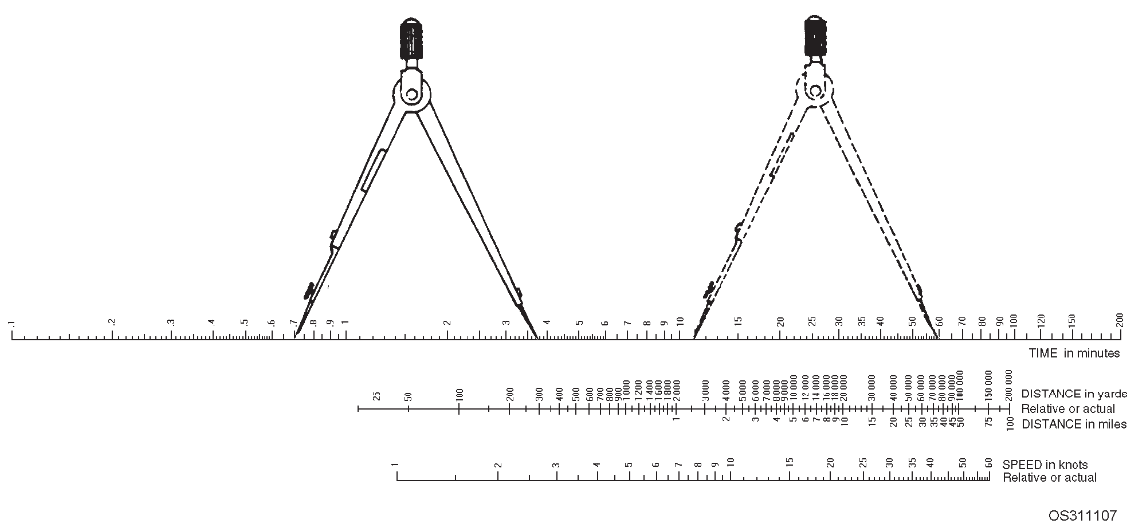

Figure 11-7.—Logarithmic scale.

ship to the contact's line of relative movement, perpendicular to the line of relative movement. It is expressed in *true* bearing and range from own ship and the time the contact should reach that point.

You can find the point and time of a contact's CPA on a maneuvering board or the surface summary plot before you solve a vector diagram for the contact's course and speed.

Normally, four plots are needed to get an accurate CPA and time of CPA solution. Check the solution approximately every 3 minutes to see if the solution still is correct. Any change in course or speed of either own ship or the other ship will result in a change in the CPA.

NOTE

Unless indicated otherwise, all courses and bearings are true (T). Also, for the problems in this chapter, you may notice slight discrepancies between the plots in the figures and the numerical solutions stated in the text. These discrepancies are within tolerances allowed (±3°, ±3 knots, ±3 minutes, and ± 500 yards) for maneuvering board problems.

Problem #1

Situation: Own ship is on course 300°, speed 15 knots. See figure 11-8. At 0530 the surface-search radar operator reports a surface contact on bearing 236° at 18,000 yards, closing. The radar operator continues to report ranges and bearings. At 0533 the contact has closed to 15,600 yards on bearing 232°. (Note: Although we stated earlier that you need four plots to get an accurate CPA solution, we will use only two points in this problem to simplify the process.)

You must determine the following information:

1. The direction of relative motion (DRM) of the contact with respect to own ship
2. The true bearing of the contact when it reaches minimum range
3. The minimum range at which the contact will pass own ship
4. The speed of relative motion of the contact with respect to own ship
5. The time at which the contact will reach CPA

Solution: As with any maneuvering board problem, your first consideration is the choice of scale. Since the contact's initial range is less than 20,000 yards but greater than 10,000 yards, the 2:1 scale is the most suitable one to fit the board and present the largest picture, enabling you to get the most accurate solution.

Determining Closest Point of Approach

First, construct a track of the contact to establish its M_1M_2, line of relative movement. Extend this line across the maneuvering board. Label the first plot M_1 and the second M_2.

Next, determine the contact's DRM. To obtain the direction of relative movement, align one side of the parallel ruler along the M_1M_2 line, then walk the rulers until the other side is positioned over the center of the maneuvering board. Mark the bearing circle at the point where the ruler on the center point crosses it. In this problem (fig. 11-8), a line drawn through the board's center and parallel to the relative movement line will cross the bearing circle at bearing 081°, so DRM is 081°.

Sometimes when you attempt to draw a contact's line of relative movement, you will find that the plot points (M_1, M_2, M_3, etc.) are not in a straight line. This may have been caused by someone's error in reporting or plotting bearing or range. If the plot is erratic, imagine a line that runs through the average or mean of the plots. Lay one edge of the parallel ruler on this line, then walk the ruler to the center of the board to find the DRM.

From the center of the board, construct a line that is perpendicular to the extended M_1M_2 line. You can make a perpendicular-to-the-relative-movement line by adding 90° to, or subtracting 90° from, the DRM, depending on the general direction from own ship to the contact. In this case, we need to add 90° to the DRM. Thus, the true bearing of the contact when it reaches its minimum range from own ship is 171° (081° + 090° = 171°). (When the answer exceeds 360°, subtract 360 from the total to obtain the CPA bearing.)

The point where the bearing line crosses the extended M_1M_2 line is the range of CPA. Measure this range from the center of the board by applying the same scale (2:1) you used to plot the positions of the contact. In the example, the range is approximately 7700 yards. This means that 7700 yards is the closest point the contact will pass to own ship, provided that neither ship changes course or speed.

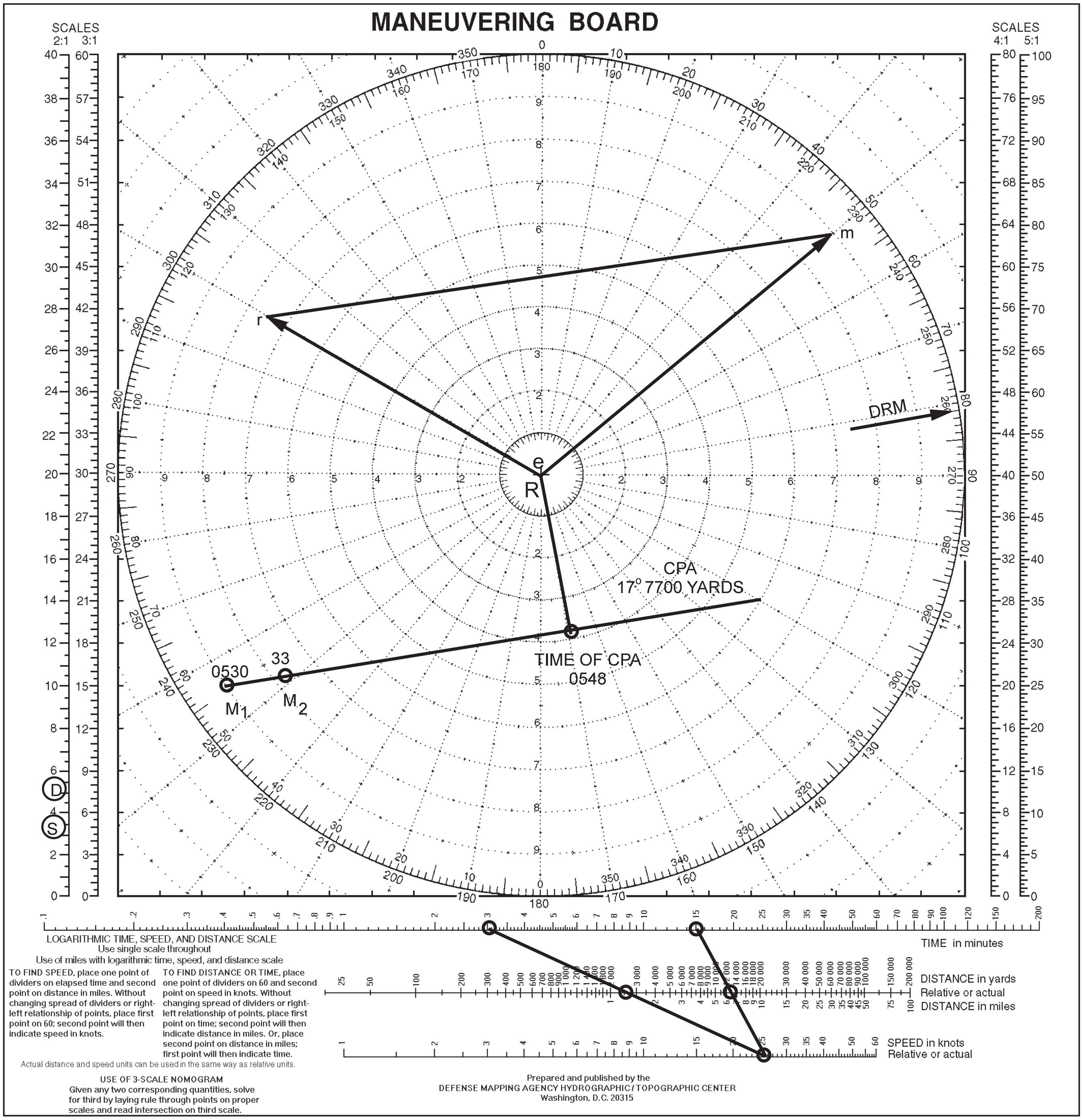

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Figure 11-8.—Course, speed and CPA problem

So far, we know the range and true bearing at which the contact will be closest to own ship. Now we need to know the time of CPA.

Determining Time of CPA

To calculate the time at which the contact will be at CPA, you must first determine the relative distance from point M_2 to the point of CPA and the contact's relative speed.

To obtain the relative speed, first measure the distance the contact moved during the 3-minute interval between 0530 and 0533. The relative distance from M_1 to M_2 is 2700 yards. Since you know a distance and its associated time, you can use the nomogram to determine the related speed. Locate 3 minutes on the time scale, then 2700 yards on the distance scale (see figure 11-8). Next, draw a straight line between the two points and extend the line through the speed scale.

The point where the line cuts across the speed scale indicates the relative speed of the contact, in this problem, 27 knots.

Determine the relative distance to CPA by measuring the distance from M_2 to CPA (13,750 yards).

You can now determine the time of CPA by applying the relative speed (27 knots) and the relative distance (13,750 yards) to the nomogram. By laying a straightedge through these two points, you will obtain a time of 15 minutes. This means that the contact will be at CPA 15 minutes from the time of M_2, or at time 0548.

CPA problems are common types that you will solve many times while standing watch in CIC. Many times, you will work them on the surface summary plot. Inasmuch as the surface plot does not have a nomogram on it, you will have to use a nautical slide rule. See figure 11-9. You will use the nautical slide rule in the same manner as the nomogram, but in many instances you will find the slide rule easier to use. If you have any doubt about using it, be sure to ask a senior Operations Specialist.

3-Minute Rule

The 3-minute thumb rule is another method of solving for relative speed. You can use it instead of the nomogram or a nautical slide rule to determine relative speed, thus saving considerable time. The 3-minute rule can be summarized in three short steps, as follows:

1. Compute the distance, in yards, traveled in 3 minutes of time.
2. Point off two places from the right.
3. The result is speed in knots.

Thus, a ship that travels 2700 yards in 3 minutes has a speed of 27 knots.

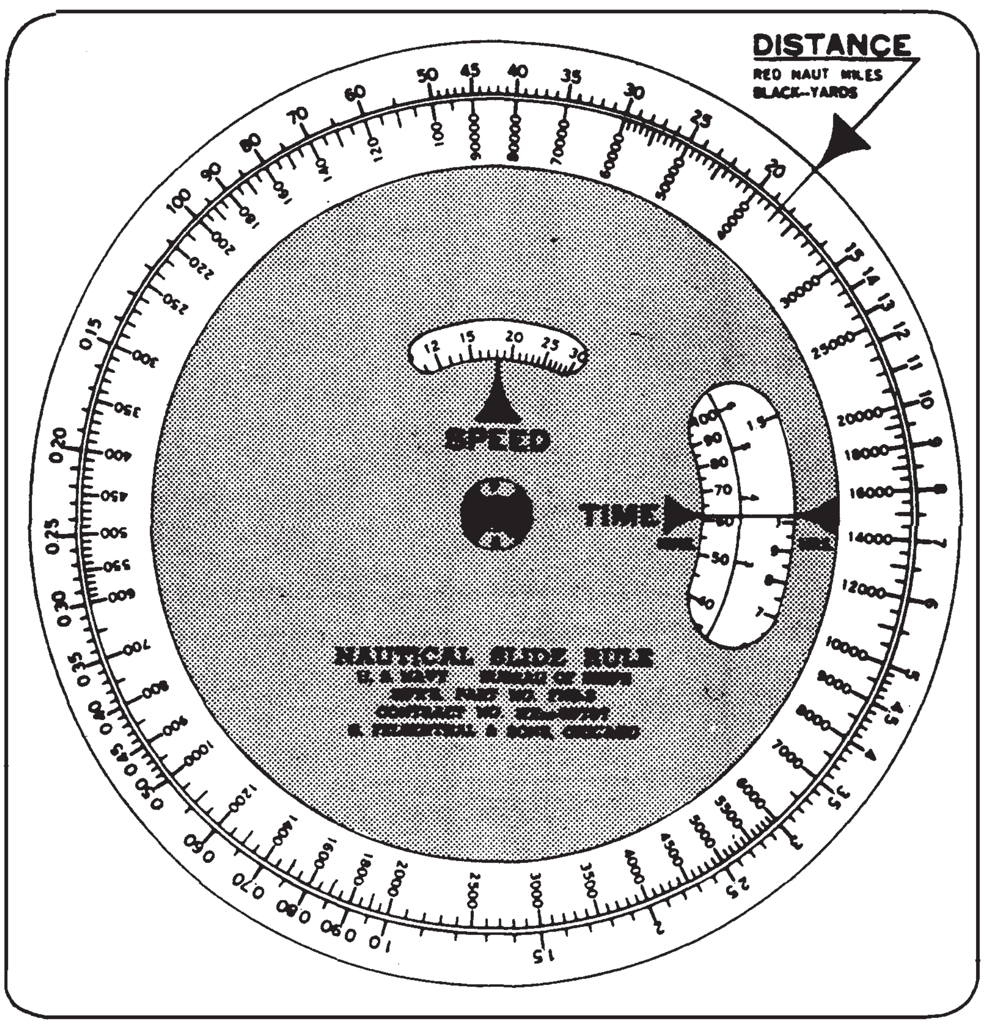

Figure 11-9.—Nautical slide rule.

Q2. Regardless of the method used to do a maneuvering board problem, where is the reference ship plotted?

Q3. What scale on the maneuvering board is used to solve for time, speed, or distance?

COURSE AND SPEED PROBLEMS

To illustrate the procedures used to obtain the course and speed of a contact, let's use the situation in the previous problem.

Own ship's course and speed are 300°, 15 knots. In figure 11-8 these are plotted as vector *er*. In this case, the outer ring represents 20 knots to make the er vector as long as possible to give the most accurate results (If the outer ring were set at 10 knots, vector *er* wouldn't fit on the board. If the outer ring were set at 30 knots, vector *er* would be shorter than it is in the figure).Since vector *er*, originates in the center of the maneuvering board, it is a true vector.

You can use much of the information you obtained in the CPA problem to also determine the contact's true course and speed. To do this, you must first draw vector *rm*, which represents the contact's DRM and relative speed.

To draw vector *rm*, first draw, through the end of vector *er*, a line of some length representing DRM. We mentioned earlier that line M_1M_2 (which represents DRM) and the vector *rm* are always parallel, and that the direction M_1 to M_2 is always the same as the direction *r* to *m*. To draw the *rm* line, place one side of your parallel rulers on line M_1M_2. Now, use the rulers to draw a line parallel to M_1M_2 through the end of vector *er.* This line represents the direction of vector *rm*. To establish the length of vector *rm*, set your dividers to 27 knots on the 2:1 speed scale. You must use the 2:1 scale because we earlier set the outer ring of the maneuvering board equal to 20 knots. Now, place one of the dividers' points at point r and the other point on the line in the direction of DRM. Label the second point m. You have drawn vector *rm*.

To determine the true course and speed of the contact, simply complete the vector diagram by drawing a line from the center of the maneuvering board to the end of the *rm* vector. This line is the *em* vector. Its direction indicates the target's true course; its length indicates the target's true speed. In this example, the contact is on course 050°, speed 18 knots.

IMPORTANCE OF LABELING

To avoid confusion, be sure to label each line or vector of the relative plot and vector diagram correctly. In addition, also mark the scales you are using. Notice in figure 11-8 that the 2:1 scale is marked with D and S. This means that the 2:1 scale is being used for both distance (D) and speed (S). These scale markings are particularly important when one scale is being used for distance and a different scale is being used for speed.

PRACTICE PROBLEMS

By now, you should have a basic understanding of how to use the maneuvering board. To help you develop skills in working various types of problems, we will now present and solve several problems associated with typical situations.

Course, Speed, and CPA Problems

Problem #1

1. Own ship's course is 090°, speed 10 knots.
2. At time 1100, Skunk A is bearing 060°, range 10,000 yards.
3. At 1101, Skunk A bears 059.5°, range 9400 yards.
4. At 1102, Skunk A bears 059°, range 8600 yards.
5. At time 1103, Skunk A bears 058°, range 8,000 yards.

Find the following:

1. CPA
2. Time of CPA
3. Course and speed of Skunk A

This problem is laid out for you in figure 11-10. Study it carefully and make sure you understand every vector and solution before proceeding any further. The answers are as follows:

1. CPA: 338°, 1300 yards
2. Time of CPA: 1115
3. Course and speed of Skunk A: 228°, 11.5 knots

Problem #2

1. Own ship's course 270°, speed 27 knots.
2. At time 1200, Skunk B is reported at 284°, range 18,000 yards.

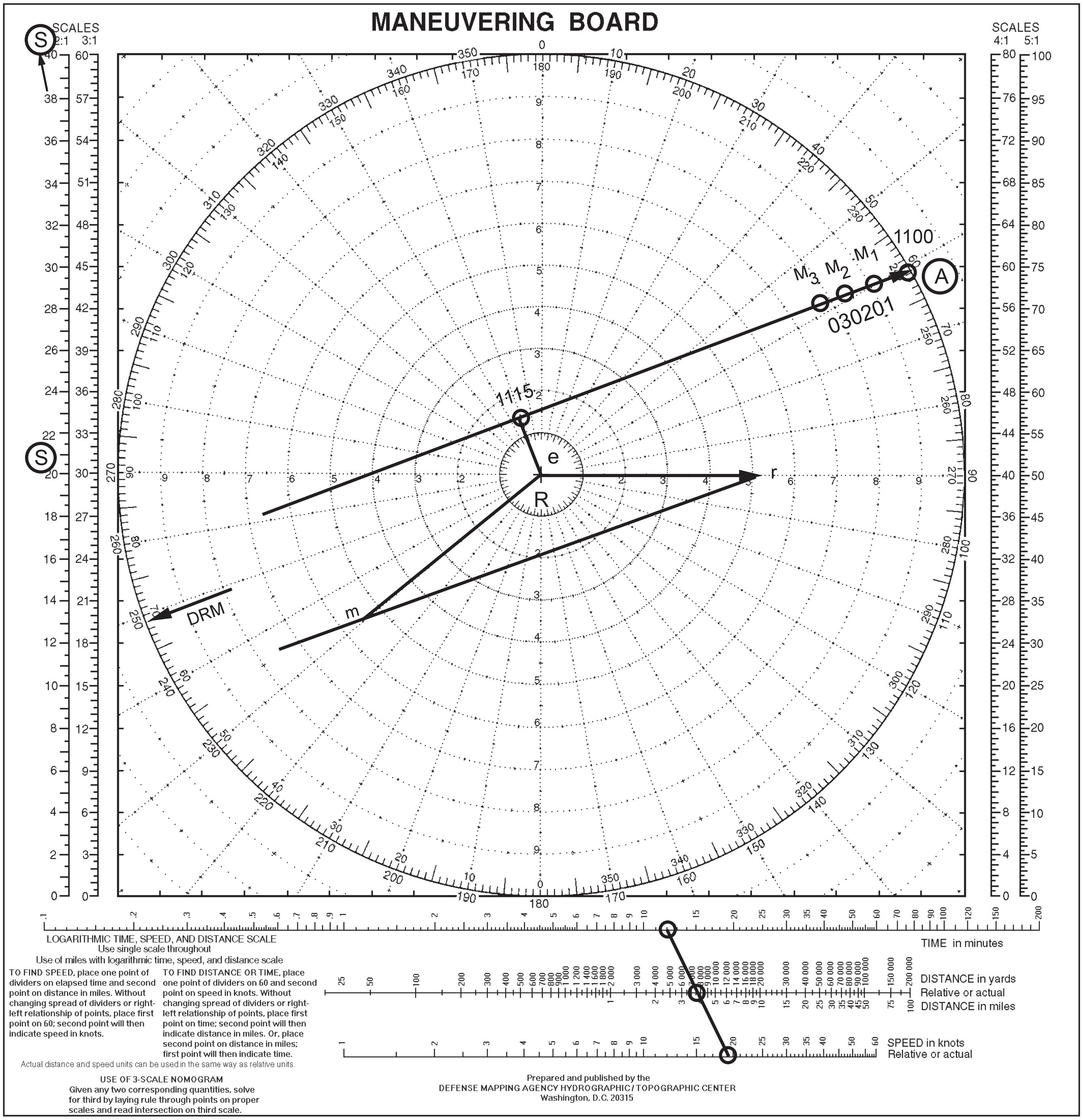

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Figure 11-10.—Course, speed and CPA problem #1.

3. At time 1202, Skunk B bears 286.5°, range 15,200 yards.
4. At time 1204, Skunk B bears 288.5°, range 12,500 yards.
5. At time 1205, Skunk B bears 291°, range 11,100 yards.

Find the following:

1. CPA
2. Time of CPA
3. Course and speed of Skunk B

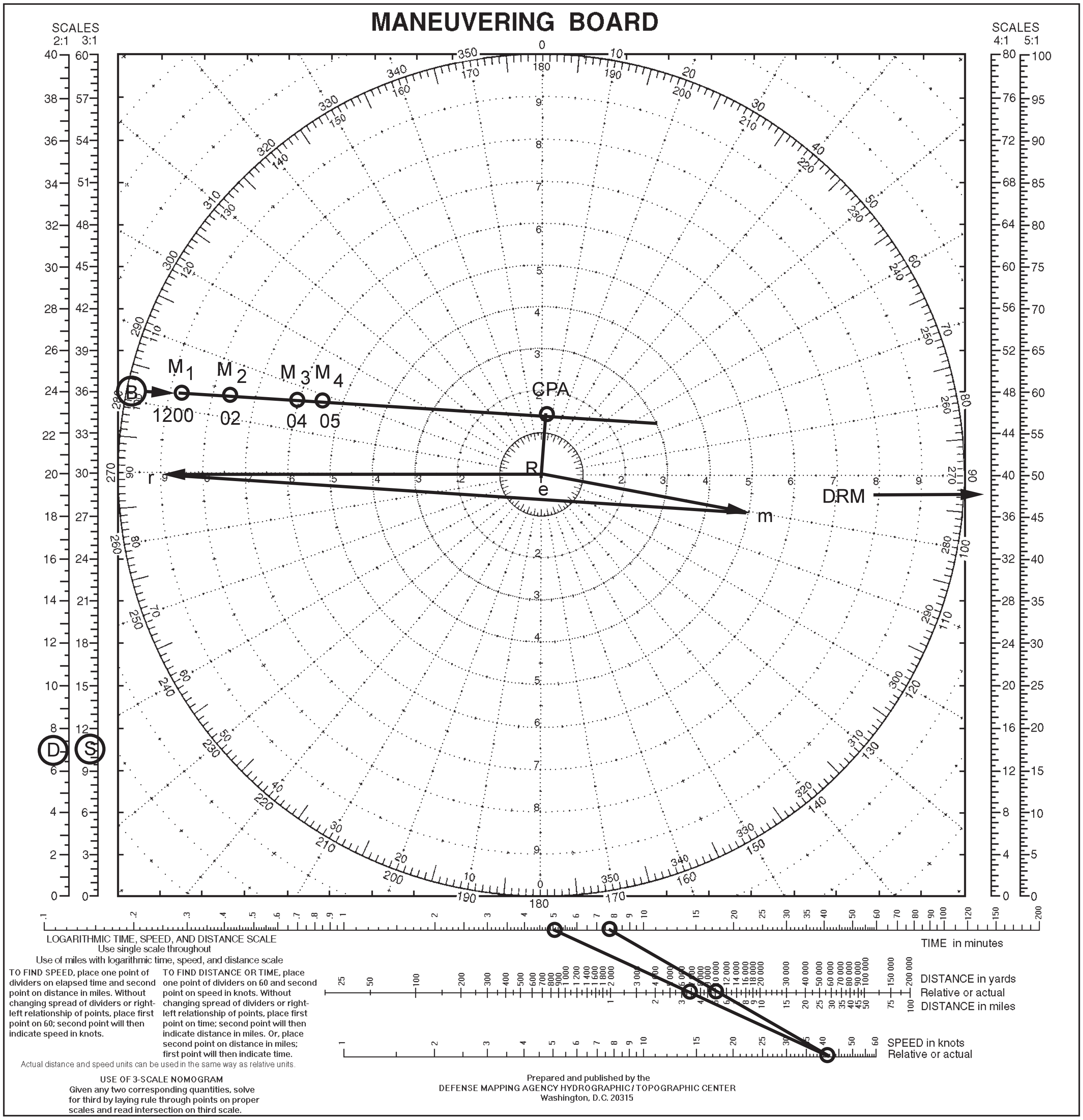

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Figure 11-11.—Course, speed and CPA problem #2.

This problem is shown in figure 11-11. Did you get the correct solutions? The answers are as follows:

1. CPA: 003°, 3450 yards
2. Time of CPA: 1212
3. Course and speed of Skunk B: 097°, 16 knots

Change-of-Station Problems

To determine the required course or speed of the maneuvering ship to go from one station to another, use basically the procedures as you used for the course and speed problems.

Problem #1

The formation is on course 020°, speed 12 knots. You are on board the flagship. Cruiser A is 18,000 yards ahead of you and is ordered to take station on the port beam of the flagship, distance 14,000 yards.

Find the following:

1. The direction of relative movement of cruiser A with respect to your ship
2. Cruiser A's course at 18 knots
3. Cruiser A's course at 12 knots
4. Cruiser A's speed if she steers 295°
5. Cruiser A's speed if she steers 350°

Solution: (Recommend the use of a scale of 2:1 for distance and speed.)

1. Draw vector *er* to represent the true course and speed of your ship.
2. Locate M_1 and M_2 and draw the line of relative motion. To locate these points, determine the true bearing of the maneuvering ship from the reference ship at the beginning and end of the maneuver. Thus, if cruiser A is ahead of you at the start of the maneuver and you are on course 020°, her true bearing from you is 020°; the distance is 18,000 yards, as given. M_2 is on your port beam, or at a relative bearing of 270° (290°T), and the distance is 14,000 yards. Place an arrowhead on the relative movement line to indicate that the direction is from M_1 to M_2. You can determine the direction of this line by transferring it parallel to itself to the center of the diagram.
3. Draw vector *rm*, parallel to $M_1 M_2$. Begin this line at r, and continue it until it intersects the 18-knot speed circle (circle 9 at 2:1 scale). Label this point m_1.
4. Complete the speed triangle by drawing vector em_1 from the center of the diagram to m_1 . The direction of this line represents the course required to produce the desired DRM at a speed of 18 knots.
5. Draw vector em_2 from the center of the diagram to the intersection of the *rm* vector with the 12-knot circle.
6. Draw vector em_3 in the direction 295° from the center to its intersection with the *rm* vector. The length of this line represents the true speed at 295°.
7. Draw vector em_4 vector in the direction 350°, determining the speed as in step 6.

Any of these combinations of course and speed of cruiser A will produce the desired relative movement.

Check your plot against figure 11-12. The answers are as follows:

1. DRM: 238°
2. Course: 262°
3. Course: 276°
4. Speed: 8.8 knots
5. Speed: 8 knots

Which of the four courses and speeds would take the greatest amount of time? Why?

Answer: Course 350°, speed 8 knots would take the greatest time, because relative speed is slowest on that course (rm_4).

If cruiser A desires to get to its new station as fast as possible, it should take the course and speed that has the highest relative speed: course 262°, speed 18 knots.

If cruiser A takes course 350° at 8 knots to go to its new station, its relative speed will be 6.4 knots. The maneuver will require 1 hour and 47 minutes to complete. However, if the cruiser takes course 262° at 18 knots, its relative speed will be 25.9 knots. It will arrive at its new station in 26 minutes. Thus, cruiser A's best course to station is 262° at 18 knots.

Problem #2

A formation is on course 090° at 15 knots. Destroyer B is located broad on your starboard bow at 20,000 yards. Destroyer B is ordered to take station 4,000 yards on your port beam, using a speed of 12 knots.

Find the following:

1. Destroyer B's best course to station at 12 knots
2. Destroyer B's time to station
3. Destroyer B's CPA to own ship

Solution:

1. Draw vector *er*: 090°, 15 knots.
2. Locate M_1 and M_2 (M_1 is at 135°, 20,000 yards; M_2 is at 000°, 4,000 yards), and draw the DRM line.

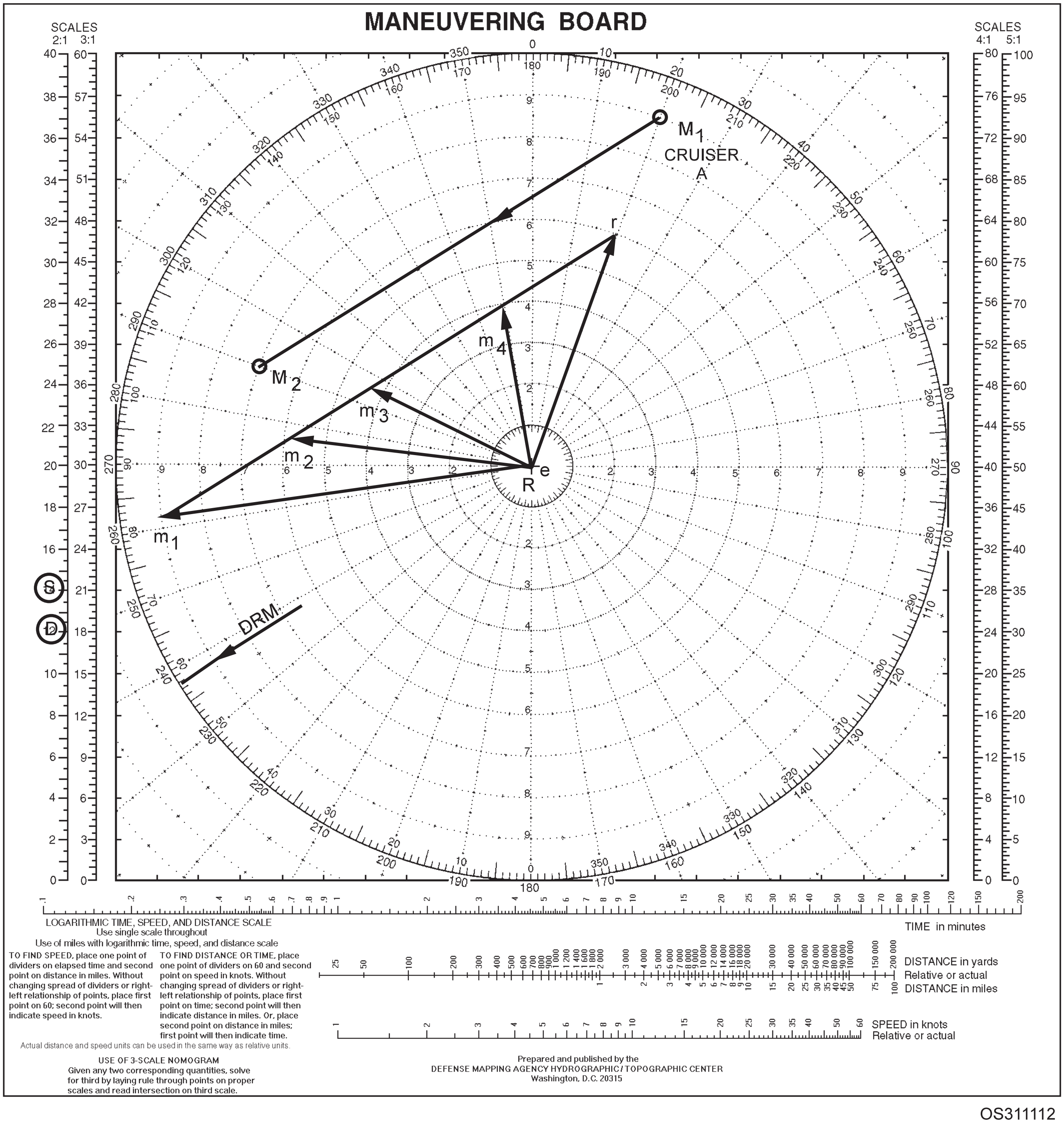

Figure 11-12.—Change-of-station problem #1.

3. Parallel the DRM line to the end of the *er* vector. This establishes the direction of the *rm* vector.

4. Complete the vector triangle by drawing vector *em* from the center to the point where the *rm* line crosses the 12-knot circle with the highest relative speed (the *rm* line crosses the circle at two points).

5. Determine relative speed by measuring the length of the *rm* vector.

6. Determine the relative distance destroyer B has to go to station by measuring the distance from M_1 to M_2.

7. Apply the relative speed and the relative distance to the nomogram to determine the time required to complete the maneuver.

8. Determine DRM and add 90° to obtain the CPA bearing (322° + 90° - 360° = 052°).

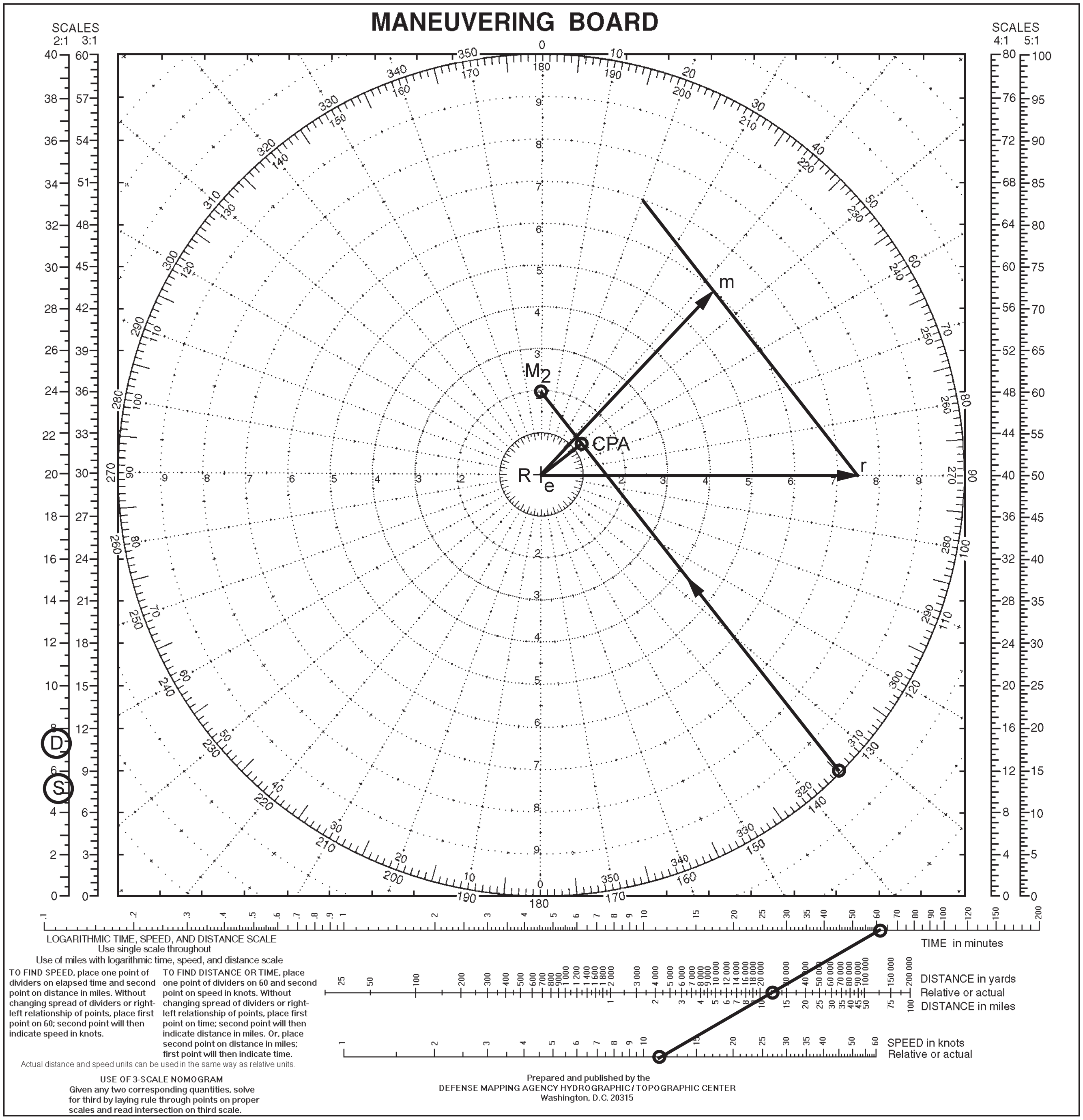

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Figure 11-13.—Change-of-station problem #2.

9. Draw a line from the center out along the CPA bearing to the point where it intersects the M_1M_2 vector.

10. Measure the distance from the center to the CPA.

Check your plot against figure 11-13. The answers are as follows:

1. Course: 043°

2. Time to station: 61 minutes

3. CPA: 052°, 2500 yards

Problem #3

Own ship is steaming independently on course 180°, speed 15 knots. You are in communications with destroyer C located at 140°, 36,000 yards at time 2000. He states that he will be passing through your area on course 270° at 20 knots.

Find the following:

1. Destroyer C's CPA
2. Time to CPA.

Solution:

1. Draw the *er* vector: 180°, 15 knots.
2. Draw the *em* vector: 270°, 20 knots.
3. Complete the vector diagram by drawing the *rm* vector.
4. Plot the M_1 position: 140°, 36,000 yards.
5. Determine DRM by paralleling the *rm* vector to the center. Direction is always from *r* to *m*; therefore, DRM is 307°.
6. Parallel to the M_1 position and draw a line from M_1 across the maneuvering board.
7. Subtract 90° from the DRM to determine the CPA bearing (307° - 90° = 217°).
8. Determine CPA range by drawing a line from the center out along the CPA bearing to the point where it intersects the extended DRM line.
9. Determine relative speed by measuring the length of the *rm* vector.
10. Determine the relative distance by measuring the distance from M_1 to CPA.
11. Determine time to CPA by applying relative speed and relative distance to the nomogram.

Check your plot against figure 11-14. The answers are as follows:

1. CPA: 217°; 8,100 yards
2. Time to CPA: 42.5 minutes

Avoiding Course Problem

To solve for avoiding a collision, use the same basic change-of-station procedures. The primary difference is in how you document the situation.

Problem:

Your ship is steaming independently on course 320°, speed 15 knots. You track a contact for a reasonable amount of time and determine that its course and speed are 197°, 20 knots and that it is on a collision course with your ship. The contact bears 353°, range 16,000 yards at time 0250. When the contact reaches 10,000 yards, your ship is to take action to avoid the contact by 3,000 yards, while not crossing its bow. You will also be required to maintain your present speed throughout the maneuver.

Find the following:

1. Course to steer to avoid the contact
2. Time to turn

Solution:

1. Draw the er_1 vector: 320°, 15 knots.
2. Draw the *em* vector: 197°, 20 knots.
3. Complete the vector diagram. Draw r_1m.
4. Plot the M_1 position: 353°, range 16,000 yards.
5. Plot the M_2 position: 353°, range 10,000 yards.
6. Draw a line from M_2 tangent to the 3,000-yard circle. To avoid crossing the contact's bow, own ship will have to turn right. Therefore, the line will be drawn to the west of own ship. Parallel this line to the *em* vector and draw the r_2m 15-knot circle. Complete the vector diagram by drawing er_2.
7. To determine the time to turn, measure the M_1 M_2 distance and relative speed of r_1m. Apply these components to the nomogram and add the results to the time designated for the M_1 position.

Check your solution against figure 11-15. The answers are as follows:

1. 003°
2. 0256

Wind Problems

Relative wind is the direction and speed from which the wind *appears* to be blowing. Relative wind seldom coincides with true wind, because the direction and speed of the relative wind are affected by own ship's movement. For example, if your ship is heading north at 10 knots and the true wind is blowing from the south at 10 knots, there appears to be no wind at all. In another situation, your ship may be heading north with the wind appearing to blow in on the port bow, but the true wind is actually coming from the port quarter. In both of these cases, the ship's movement is affecting the relative wind.

You can figure wind problems on a maneuvering board by using basically the same procedures as for course and speed problems. There are, however, a few new terms:

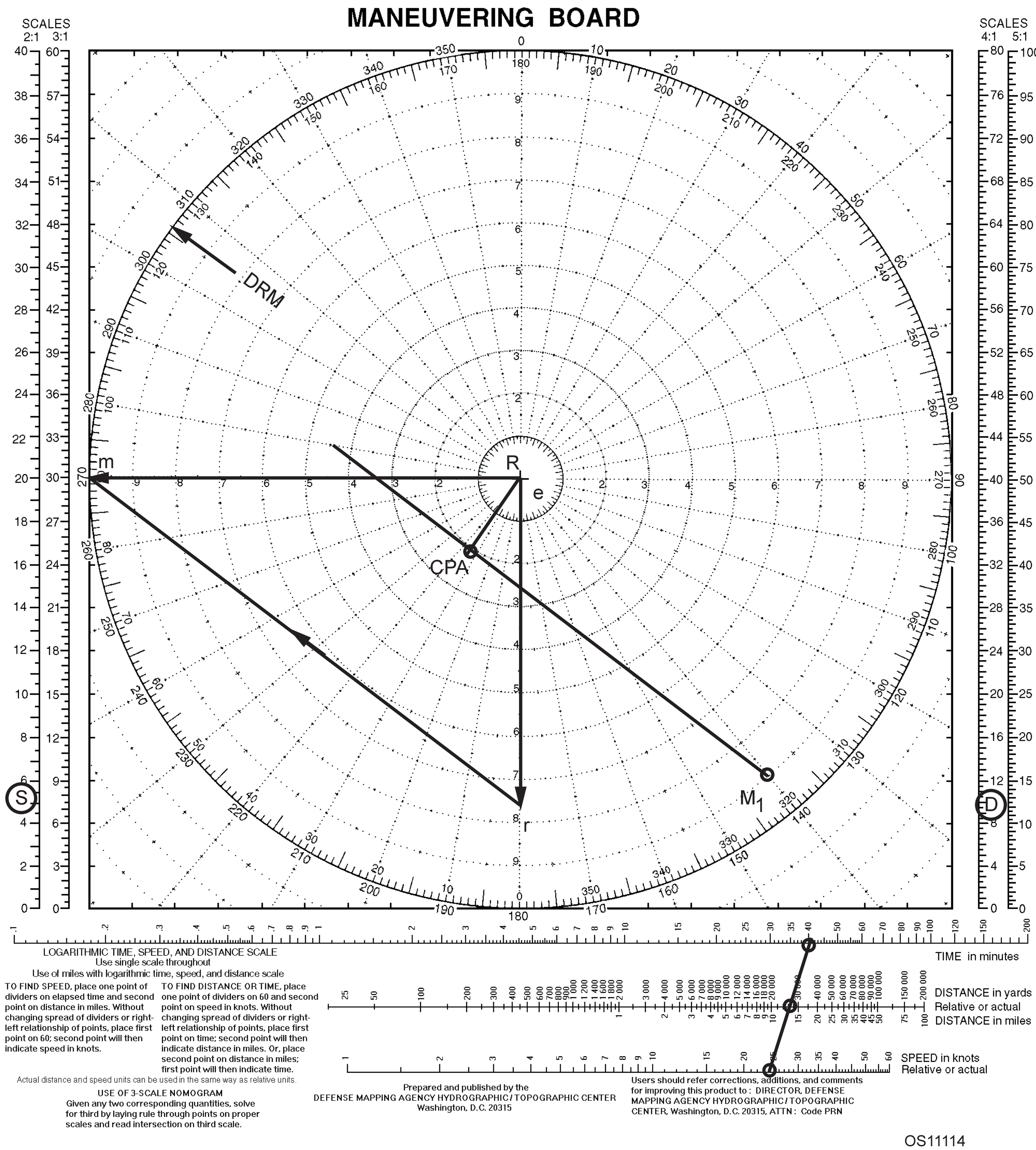

Figure 11-14.—Change-of-station problem # 3.

course and speed problems. There are, however, a few new terms:

1. True wind (TW) is the velocity and direction from which the true wind is blowing.

2. Relative wind (RW) is the velocity and relative direction from which the wind is blowing in relation to ship's head (SH).

3. Apparent wind (AW) is the velocity and true direction from which the relative wind is blowing. For example, if your ship is heading 090° and a 15-knot relative wind is blowing in on your starboard bow (045°), the apparent wind is from 135°T at 15 knots. The formula for apparent wind is AW = RW +SH.

4. An anemometer is an instrument for measuring the velocity of the wind. Some shipboard anemometers indicate relative wind, while others indicate apparent wind.

When determining true wind, you must be careful to note whether relative or apparent wind is given.

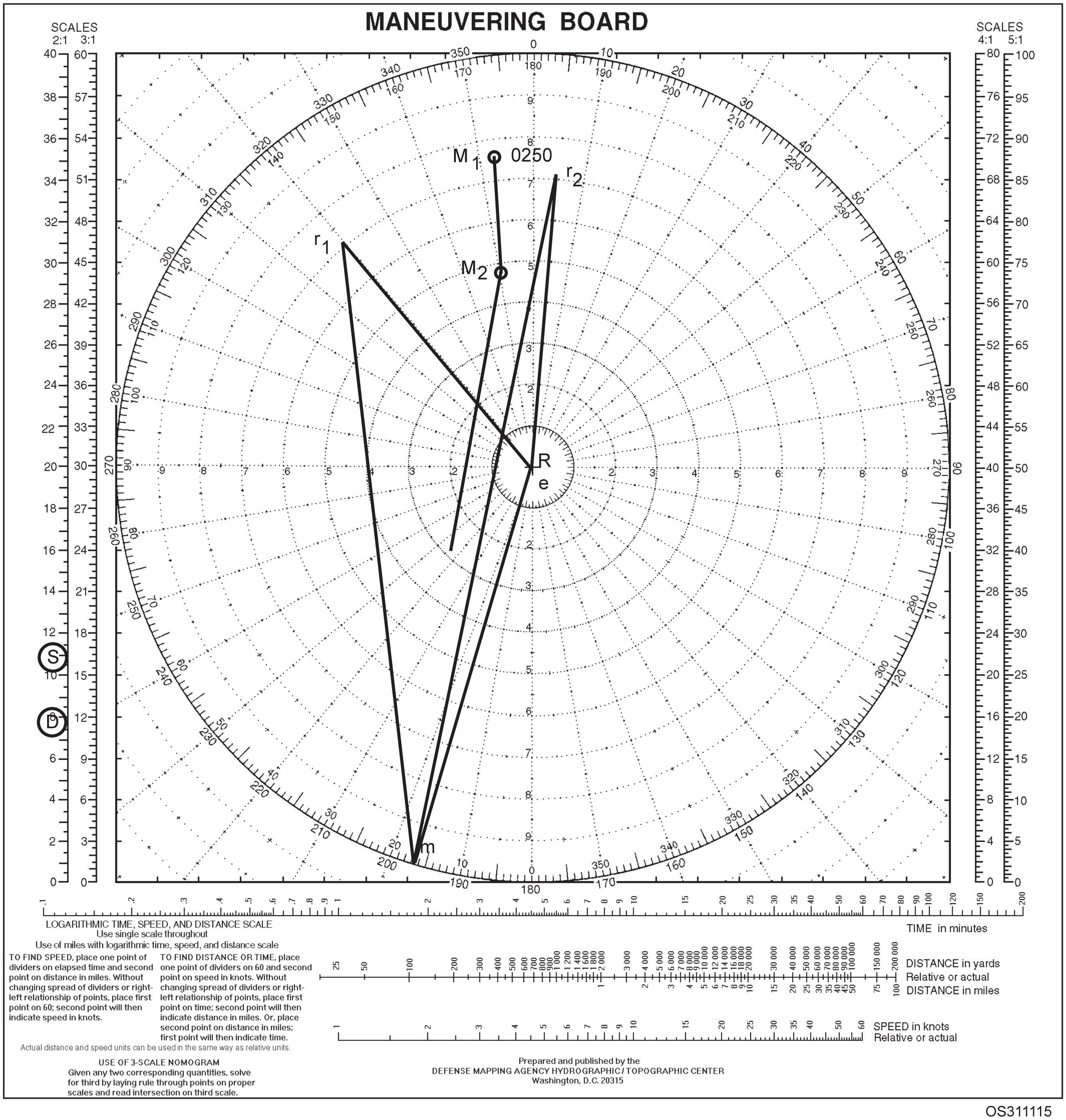

Figure 11-15.—Avoiding course problem.

Wind direction is always the direction from, NOT to which the wind is blowing.

In the vector diagram for a wind problem, the vectors are labeled as follows:

1. *er*—own ship's course and speed
2. *et*—true wind
3. *ra*—relative wind

Remember, wind is always expressed in terms of the direction it is coming from, and the et and ea vectors are the direction and speed of the true and relative wind.

NOTE

You will not draw the ea vector on the maneuvering board, but you must visualize it.

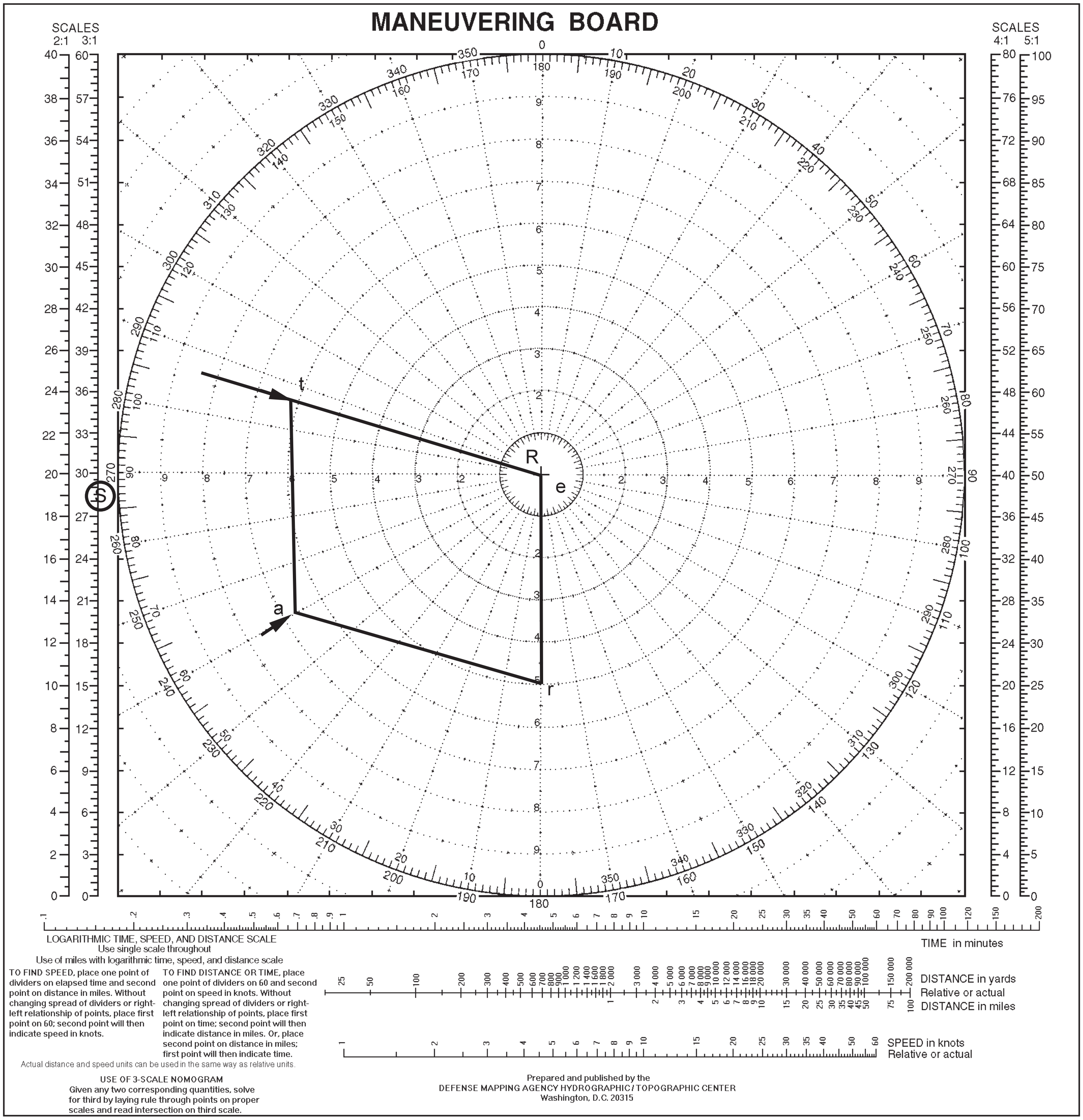

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Figure 11-16.—Vector diagram for a wind problem.

Figure 11-16 shows the vector diagram for a typical wind problem. In this case, own ship's course is 180°, speed 15 knots. Draw this as vector *er*. The relative wind is from 060°R at 20 knots. Plot this point and label it as *a*. You can also express relative wind as apparent wind. In this case the apparent wind is 240°T, 20 knots. Plot the relative, apparent, and true wind with the arrows pointing toward the center of the maneuvering board.

Lay the parallel ruler on points *r* and *a* (*ra* vector) and draw a line between the two points. Now draw a line slightly longer than and parallel to the *ra* vector through the center of the maneuvering board. This will be the direction the true wind is coming from (*et*). Now, lay the parallel ruler on the *er* vector (ship's course and speed). Parallel over to the relative wind (*a*) and draw a line until it crosses the *et* vector line that you drew from the center of the maneuvering board. The point where

the two lines cross will represent the TRUE wind (direction and speed). When you have worked the problem correctly, you will have drawn a parallelogram with all the points connected (*e* to *r*, *r* to *a*, *e* to *t*, and *a* to *t*).

NOTE

The relative wind will always fall between the ship's head and the true wind.

Problem #1

Own ship is on course 030° at 12 knots. The relative wind is from 310°R at 19 knots.

Find the following:

1. Apparent wind direction
2. True wind velocity and direction

Solution:

1. Relative wind from 310°R at 19 knots converts to an apparent wind from 340°T at 19 knots.
2. Draw vector *er*.
3. Plot point *a*.
4. Parallel the *ra* vector to the center of the maneuvering board and draw a line slightly longer than the *ra* vector.
5. Complete the *et* vector by paralleling the *er* vector to *a* and drawing a line until it crosses the *et* line.

Check your solution against figure 11-17. The answers are as follows:

1. The apparent wind is from 340T.
2. The true wind is from 301 at 14.6 knots.

Problem #2

Own ship's course 250°, speed 20 knots. The apparent wind is from 230°T at 27 knots.

Find the following:

1. Relative wind direction
2. True wind velocity and direction

Solution:

1. The apparent wind from 230°T at 27 knots converts to a relative wind of 340°R at 27 knots.
2. Parallel the *ra* vector to the center of the maneuvering board and draw a line in the direction of *a*.
3. Complete the *et* vector by paralleling the *er* vector to *a* and drawing a line until it crosses the *et* line.

Check your plot against figure 11-18. The answers are as follows:

1. The relative wind is from 340°R.
2. The true wind is from 190° at 11 knots.

Desired Wind Problems

Practically every ship in the fleet conducts flight operations. Flight operations always involve a desired relative wind. Carriers must adjust their course to get the relative wind required to launch or recover aircraft. Even the smallest ships have to make course adjustments to get the relative wind needed for helicopter operations (transfer of mail, personnel, cargo, etc.). In these types of situations, Operations Specialists must solve desired wind problems to determine, from a known true wind, the course and speed the ship must use to obtain the required relative wind.

You must become proficient in computing desired wind problems, since these solutions are almost always provided by CIC. Although there are several methods that you can use to work desired wind problems, the dot method, described in the following paragraphs, is generally considered to be the best.

Problem #1

Assume that true wind is from 180° at 15 knots, and your ship needs a relative wind 30° to port at 20 knots. Follow the steps below on figure 11-19.

1. Draw the true wind course and speed vector from the center of the board toward 000° at 15 knots. (Use the 3:1 scale.) Imagine a ship pointing down the true-wind course line.
2. Plot dot number 1 on the 20-knot circle 30° from the true wind course line, on the port side of the imaginary ship. Before going any farther, be sure you understand this point. As you are looking out from the center, dot 1 is plotted 30° on the port side of the imaginary ship, on the 20-knot circle.
3. Determine the position of dot number 2 by measuring the true wind speed (15 knots in this problem) and swinging an arc from the dot-1 position across the true-wind course line, as shown in figure 11-19. Label the point or points where this arc crosses the true-wind course line

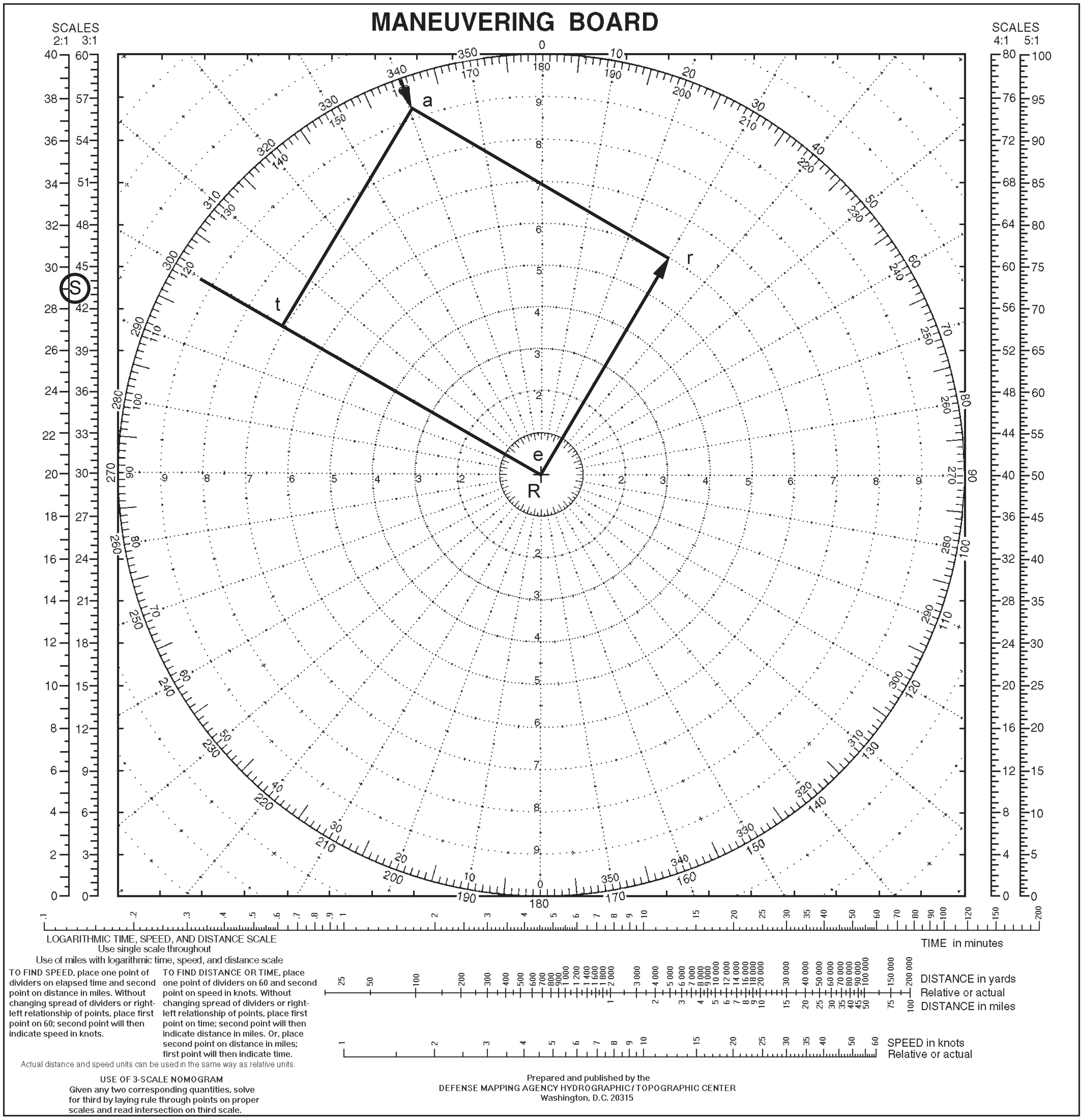

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Figure 11-17.—Wind problem # 1.

dot number 2. In most desired wind problems there will be two dot-2 positions, giving you a choice of two different course and speed combinations to obtain the desired wind.

4. Determine the required ship's courses by paralleling the dot 1-dot 2 lines to the center of the maneuvering board. In figure 11-19 the two possible courses are 318° and 222°.

5. Determine the required speed for each course by measuring from the center of the maneuvering board to the associated dot-2 position. If your ship takes course 318°, its speed must be 28.4 knots to obtain a relative wind 30° to port at 20 knots. If it takes course 222°, its speed must be 6.2 knots.

6. Complete the two *er* vectors by laying each speed onto its course line. The ship's

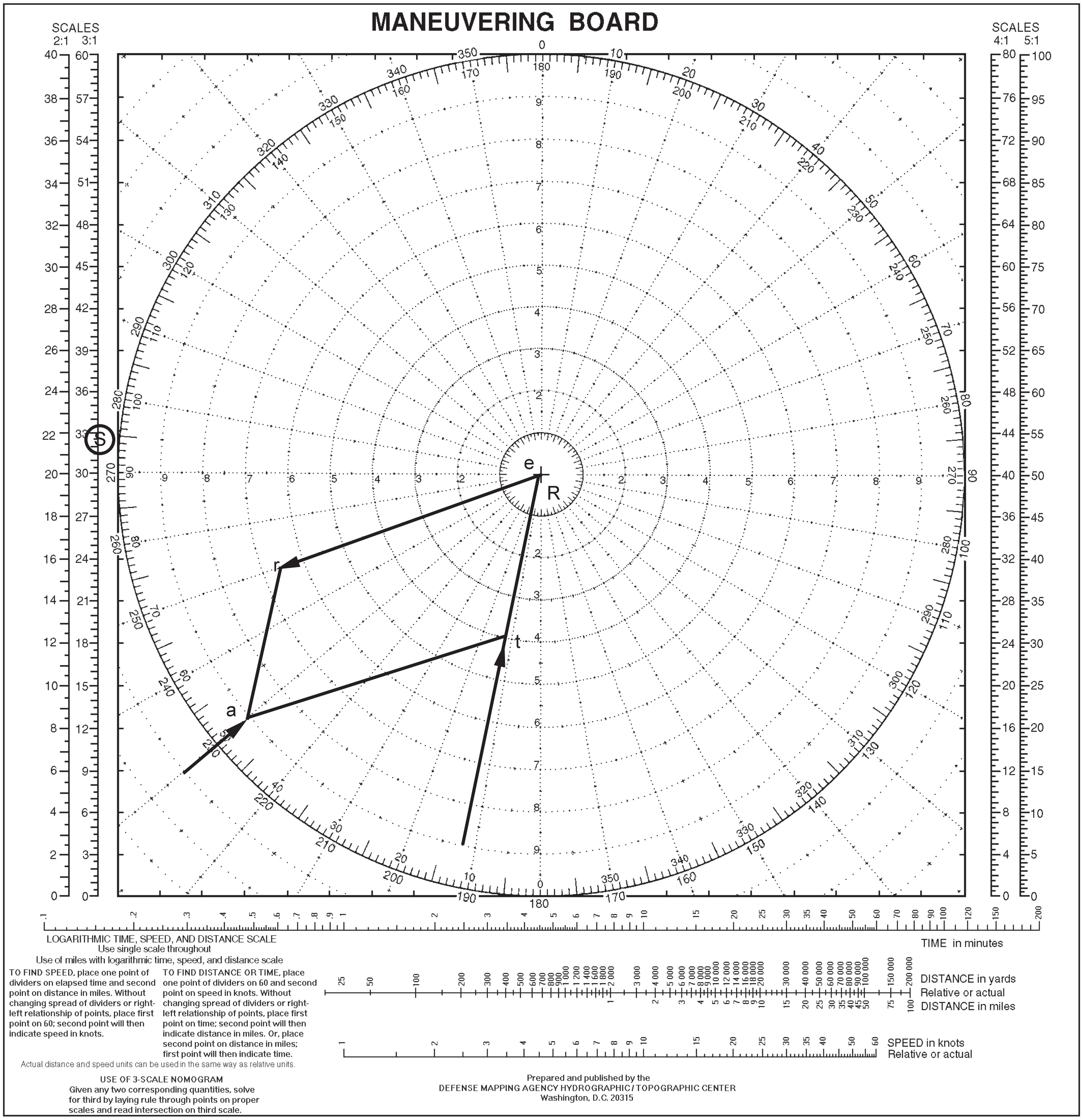

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Figure 11-18.—Wind problem #2.

characteristics and the tactical situation will usually dictate which of the two courses and speeds is best.

Problem #2

The true wind is from 320° at 20 knots. Determine the ship's course and speed necessary to create a relative wind of 020°R (20° starboard) at 30 knots.

1. (See figure 11-20) Plot the true wind
2. Looking out from the center, plot dot 1 20° to starboard of the imaginary ship, on the 30-knot circle. (Use the 5:1 scale.)
3. From dot 1, swing a 20-knot arc (true-wind speed) across the true-wind course line.
4. Plot dot 2 at the point where the arc crosses the true-wind course line.

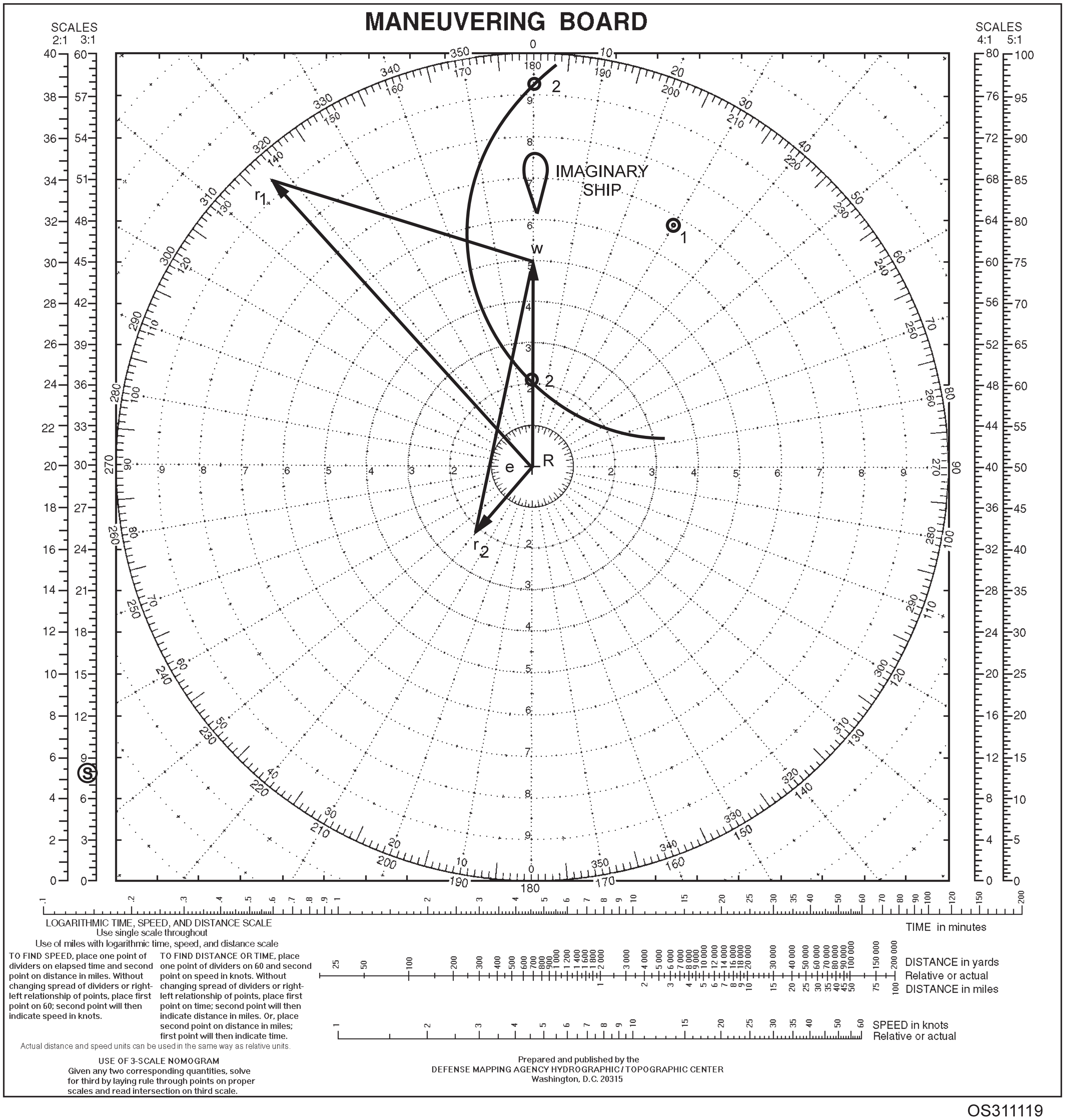

Figure 11-19.—Desired wind problem #1.

5. Parallel the dot 1-dot 2 line to the center to determine ship's required course.
6. Measure from the center of the board to dot 2 to determine ship's speed.
7. Complete the vector diagram.

In this problem, the two solutions are 289 at 11 knots and 171 at 45.5 knots. Since a speed of 45.5 knots is not practical, we will consider only the first solution.

Check your plot against figure 11-20. Course 289° and a speed of 11 knots are required to obtain a relative wind of 020°R at 30 knots. If you check the *rw* vector

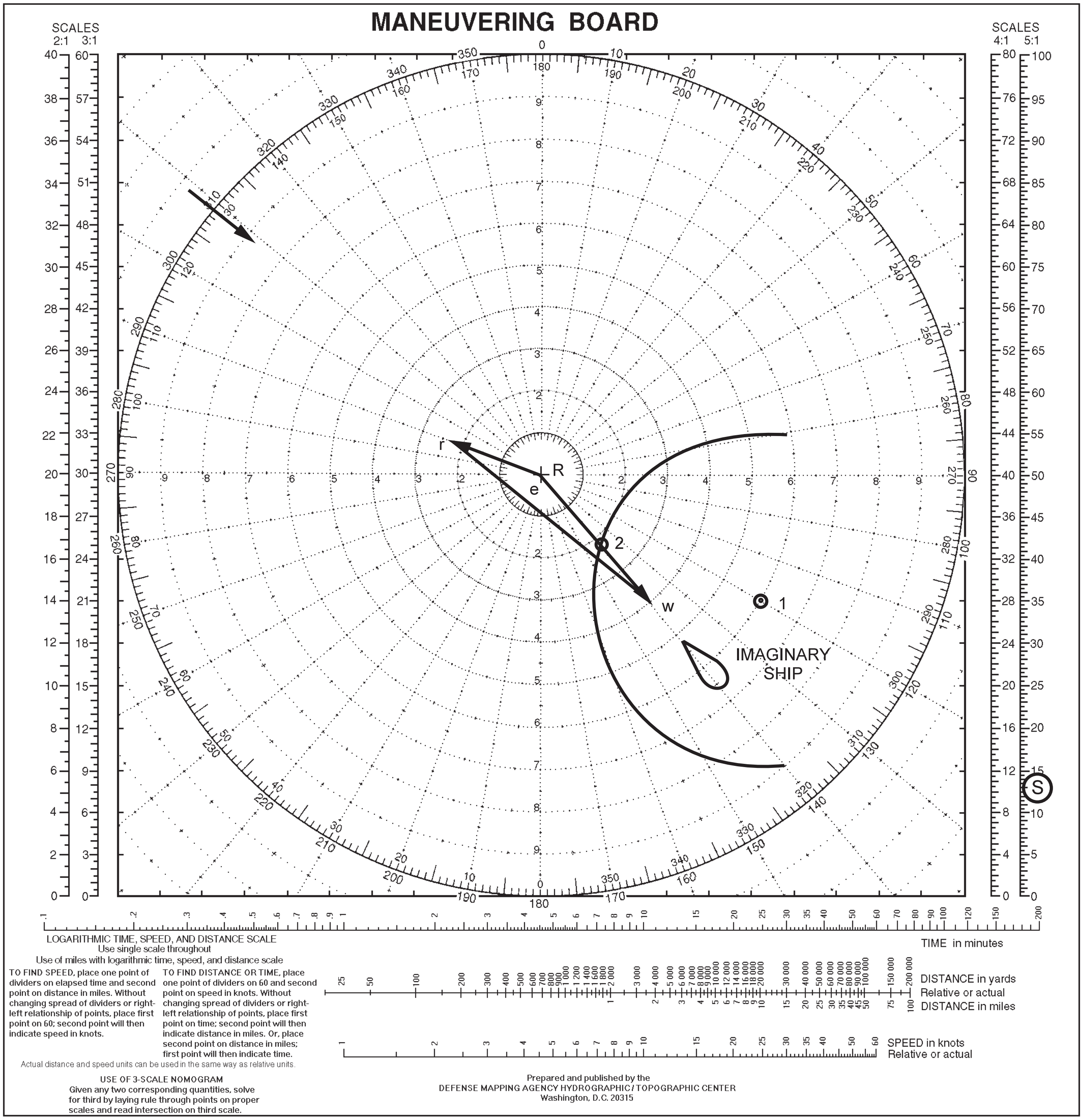

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Figure 11-20.—Desired wind problem #2.

direction and length, you will see that the apparent wind is from 309°T (020°R) at 30 knots.

Desired Wind (Alternate Method)

Problem

An aircraft carrier is proceeding on course 240° at 18 knots. The true wind is from 315° at 10 knots. Determine a launch course and speed that will produce a relative wind across the flight deck of 30 knots from 350° relative (10° port). Refer to figure 11-21.

Solution

Set a pair of dividers for 30 knots using any convenient scale. Place one end of the dividers at the origin (*e*) of the maneuvering board and the other on the 350° line. Mark this point *a*. Set the dividers for the true-wind speed of 10 knots and place one end on point

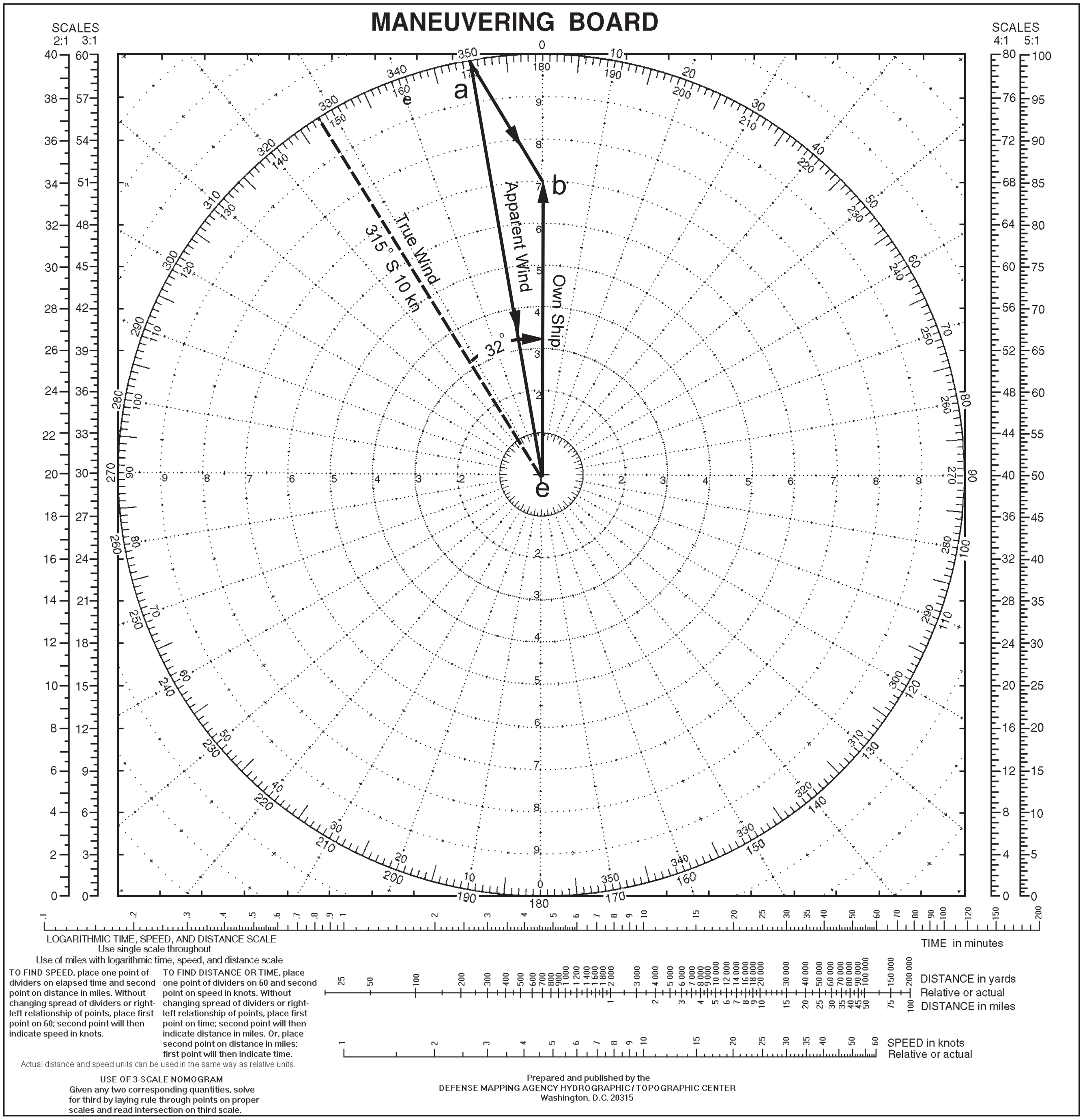

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Figure 11-21.—Desired wind (alternate method).

a, the other on the 000° line (centerline of the ship). Mark this point on the centerline *b*. Draw a dashed line from origin *e* parallel to *ab*. This produces the angular relationship between the direction from which the true wind is blowing and the launch course. In this problem the true wind should be from 32° off the port bow (328° relative) when the ship is on launch course and speed.

The required course is 347 (315° + 32°); the required speed is 21 knots.

NOTE

On a moving ship, the direction of true wind is always on the same side and aft of the direction of the apparent wind. The difference in

directions increases as the ship's speed increases. That is, the faster a ship moves, the more the apparent wind draws ahead of the true wind.

MANEUVERING BOARD TECHNIQUES

In this chapter, we have tried to show you how to solve basic maneuvering board problems. Now we offer a few hints on how you can avoid making mistakes as you work those problems.

1. Be sure to read the problem carefully; be certain you understand it before you proceed with the solution. Check all of the numbers carefully.
2. Avoid using reciprocals. When a bearing is given, be sure you understand to which ship the bearing applies or from which ship it is taken ("bearing to" or "bearing from").
3. Be particularly careful of the scale of the nomogram at the bottom of the form.
4. Measure carefully. It is easy to select the wrong circle or to make an error of 10° in direction. Read your plotted answers carefully.
5. Plot only true bearings. If a relative bearing or compass direction is given, convert it to a true direction before plotting it.
6. Label all points, and put arrowheads on vectors as soon as you draw them.
7. Remember that DRM and relative speed are the direction and length of the *rm* vector. The direction is always from *r* to *m*.
8. Remember that true vectors always originate in the center of the maneuvering board and that relative vectors originate outside the center.
9. Remember that vectors indicate direction of motion as well as speed. Thus, motion along the relative movement line is associated with relative speed, not actual speed. You can determine relative speed when you know relative distance and time. To obtain actual speed, you must know actual distance and time.
10. Remember that the maneuvering board moves with the reference ship.
11. Do not attach undue significance to the center of the maneuvering board. This point is used both as the origin of actual speed vectors and as the position of the reference ship merely for the sake of convenience.
12. Work a problem one step at a time. An entire problem may seem complicated, but each step is simple, and often suggests the next step. Remember that all problems are based on a few simple principles.
13. Remember to use the same scale for all speeds and to draw all distances to a common scale.

We suggest that you refer to this list periodically, because almost every maneuvering board mistake is based either in violating one of these rules or on making simple arithmetic errors.

ANSWERS TO CHAPTER QUESTIONS

A1. *The motion of one object with respect to another object.*

A2. *In the center of the maneuvering board, labeled as R .*

A3. *The logarithmic scale based on the two of the time, speed, or distance values that you know.*

CHAPTER 12

CHARTS, GRIDS, AND RADAR NAVIGATION

LEARNING OBJECTIVES

After you finish this chapter , you should be able to do the following:

1. Identify important aspects of charts, such as type of projection, indicated distances, soundings, and symbols.
2. Identify and discuss the procedures for using grid systems found in CIC.
3. Explain the procedures for maintaining a chart library.
4. Discuss the CIC personnel and procedures involved in navigating a ship.

INTRODUCTION

An important aspect of CIC operations is radar navigation. Poor visibility will normally prevent ships from entering or leaving port, because of the obvious additional risk involved. However, there are times when ships must enter or leave port despite poor visibility. At these times radar navigation becomes vital and CIC personnel must perform at their best. Any time ships are underway, good weather or bad, CIC maintains a navigational picture to aid the bridge in determining the ship's position and to provide command with an accurate strategic plot. Charts are vital to this navigational effort. When you finish this chapter, you should be familiar with the chart system, as well as the navigation procedures and techniques necessary for you to function as an Operations Specialist in CIC.

CHARTS

A *nautical chart* is a map designed specially for navigators. It provides a photo-like view of some body of navigable water, together with the topographic features of adjacent land. To help the navigator transit the body of water safely, the chart contains standard symbols, figures, and abbreviations that supply data on water depth, the character of the bottom and the shore, the location of navigational aids, and other useful information. Figures indicating water depth are scattered over a chart but are more numerous near approaches to land.

LOCATING POSITIONS ON CHARTS

A chart represents a section (large, medium, or small) of the Earth's surface. The Earth is a terrestrial sphere with the North Pole and South Pole located at opposite ends of the axis on which it rotates. To establish an object's location geographically, you must use one reference line running in a north-south (N-S) direction and another one in an east-west (E-W) direction. These lines are part of a circular navigational grid located on the surface of the Earth (See figure 12-1.)

Since the navigational grid is located on a sphere, and navigational charts are flat, the grid lines must somehow be transferred from the sphere to the

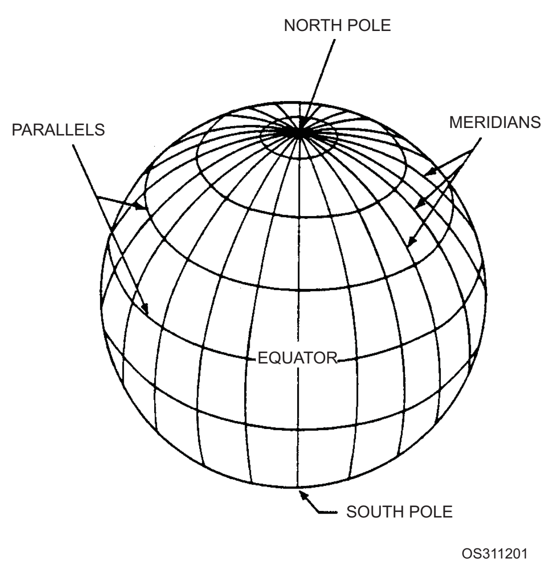


Figure 12-1.—The terrestrial sphere.

chart. This is done through a process called *projection*. There are two types of projection—Mercator and gnomonic.

MERCATOR PROJECTION

Mercator projection charts are the most commonly used charts in CIC. It is important, therefore, that you understand the construction, advantages, and disadvantages of the Mercator system.

If you cut a hollow rubber ball in half and try to flatten one of the halves, you will not be able to do so without tearing or stretching the rubber. In fact, no section of the hemisphere will lie flat without some distortion. Projection of the curved surface of the Earth onto a flat plane presents the same difficulty. Since distortion can present major problems in navigation, limiting distortion to the absolute minimum is a primary goal. The best method for projecting the surface of a sphere onto a flat surface is to project it onto the inside of a cylinder surrounding the sphere and to open the sphere and lay it flat. In this procedure, known as a Mercator projection, there is still some distortion, but it is limited and can be overcome.

The first step in drawing a Mercator projection is to project the N-S lines, or *meridians*. Assume that Earth is a hollow, transparent glass ball with a powerful light shining in its center. A paper cylinder is placed around it, tangent at the equator, as shown in figure 12-2. Suppose the meridians painted on the glass ball are projected onto the cylinder as vertical lines, parallel to

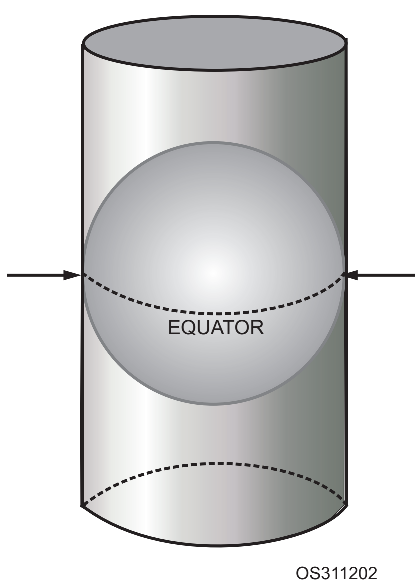


Figure 12-2.—Cylinder tangent to the Earth at the equator.

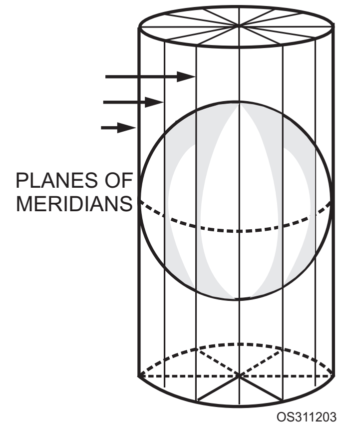


Figure 12-3.—Projection of meridians onto the cylinder.

and equidistant from one another. See figure 12-3. The cylinder now has the meridians on its surface, and half of the Mercator projection is complete.

The next step in the projection process is to draw the E-W lines, or *parallels*. The spacing of the parallels agrees mathematically with the expansion of the longitude scale. When parallels are projected onto the cylinder, they become farther apart as their distance from the equator increases. The North and South poles cannot appear at all, because one pole is projected out the top of the cylinder and the other pole is projected out the bottom.

If we now unroll the cylinder and look at the projection (fig. 12-4), we will see that the meridians are parallel to and equally distant from one another. The latitude lines are parallel to one another, but they gradually draw apart as they become farther north or south of the equator. Above 80°N or below 80°S latitude, the latitude lines become so far apart that a

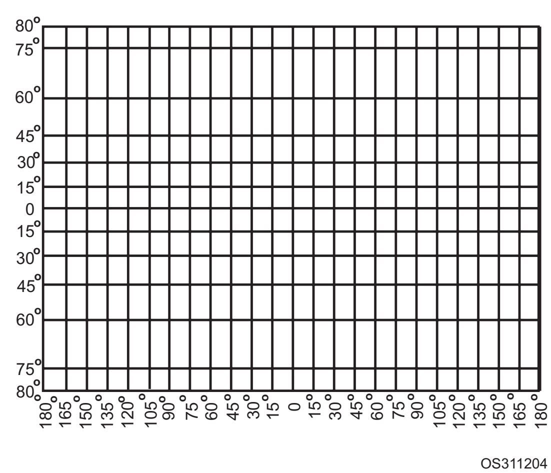


Figure 12-4.—Meridians and parallels on the Mercator projection.

Mercator projection of the polar regions is seldom used.

Although the space between parallels on a Mercator chart increases with latitude, the distance represented by 1° of latitude is always the same. One minute of latitude is considered to be 1 nautical mile. On a Mercator projection, however, 1° of latitude near one of the poles appears considerably longer than 1° of latitude near the equator. It follows, then, that if both measurements represent the same actual distance, any distance as shown in high latitudes on a Mercator chart is greatly distorted.

You have only to look at figure 12-5 to realize the truth about distortion. On the globe you see the actual comparative sizes of Greenland and the United States. The United States actually is a good deal larger than Greenland. But on the Mercator chart in the background, Greenland appears to be larger than the United States. This illusion occurs because the United States, being much nearer to the equator, is not distorted nearly as much as Greenland, which is in a high latitude.

GNOMONIC PROJECTION

The details of a gnomonic projection are not especially useful to surface navigators and, therefore, are of little use to an Operations Specialist Third or Second. You simply need to know that gnomonic projection preserves the natural curvature of the meridians and parallels, so you see them as though you were looking directly at a point on the surface of the Earth. If the point happens to be one of the poles, the parallels appear as a series of concentric circles, and the meridians are straight lines radiating away from the pole.

Polar charts usually are gnomonic projections because, as you already learned, a Mercator projection of the polar regions cannot be used.

CHART TERMINOLOGY

We mentioned earlier that to locate a point on a chart, we must reference the point to a specific meridian and a specific parallel. To identify the meridians and parallels, we use numerical designators drawn from the circular grid. Each circle in the grid is divided into 360° (degrees); each degree can be divided into either 60’ (minutes) or 3600" (seconds). Remember, lines running in the N-S direction, from pole to pole, are called *meridians*. Lines running E-W, around the entire globe, are called *parallels*.

Meridians

The charting grid contains 360 meridians. The reference line for all meridians is the *prime meridian* (0°), which passes through the Royal Observatory at Greenwich, England. The remaining meridians are

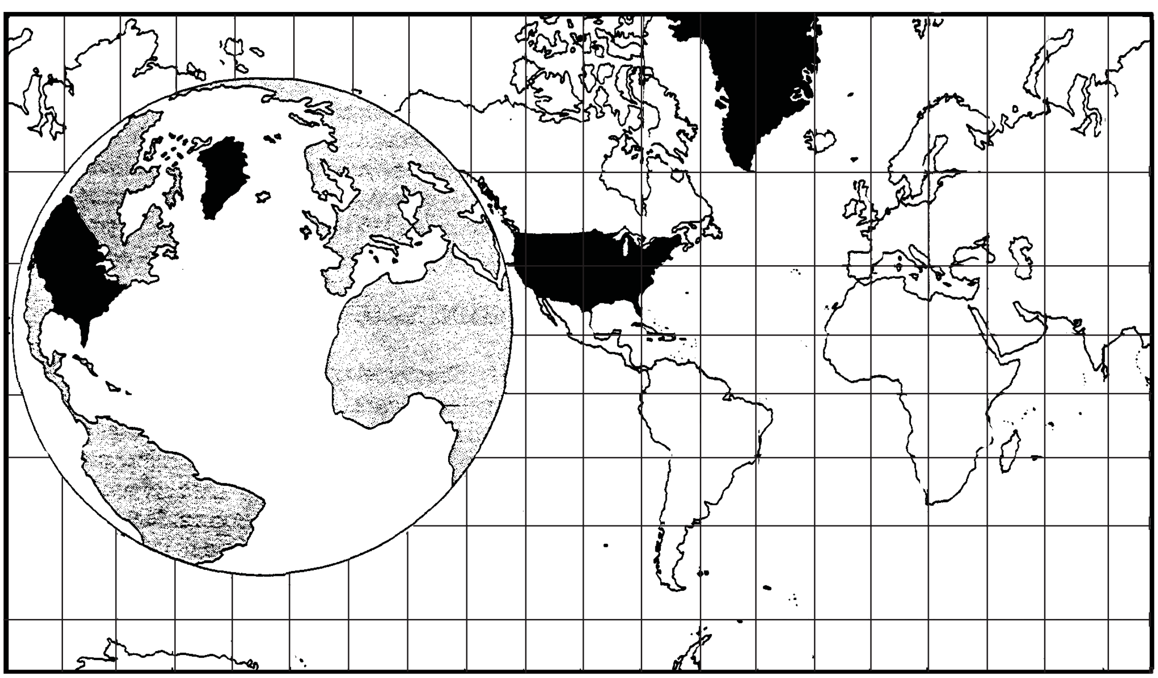


Figure 12-5.—Distorton on a Mercator chart.

numbered from 1° to 180°, both east and west of the prime meridian. Meridians located east of the prime meridian are designated as 1°E to 180°E and make up the *eastern hemisphere* of the Earth. Meridians located west of the prime meridian are designated as 1°W to 180°W and make up the *western hemisphere* of the Earth.

Parallels

The reference for parallels is the *equator.* The equator (0°) is located halfway between the poles and divides the globe into northern (N) and southern (S) hemispheres. The numbering system for parallels is similar to the numbering system for meridians, except that since parallels completely encircle the globe, 90° is the maximum number of degrees that can be assigned to a parallel. Parallels are numbered from 0° at the equator to 90°N at the North Pole and 90°S at the South Pole.

Latitude and Longitude

Every spot on the Earth is located at a point of intersection between a meridian and a parallel. Every point's location is described in terms of *latitude* and *longitude*.

The latitude of a point is the point's angular distance in degrees, minutes, and seconds of arc *north or south of the equator, measured along the meridian that runs through the point*. See figure 12-6.

The longitude of a point is the angular distance in degrees, minutes, and seconds of arc *east or west of the 0° meridian, measured along the parallel that runs through the point*. See figure 12-6.

For navigational purposes, accuracy demands are rigid. The EXACT position must be designated. Consequently, when you are giving navigational distance, remember that 1° is divided into 60' (minutes), and 1' (minute) is divided into 60" (seconds). Thus, a position of latitude may be 45°12'22"N (or S). The same system is used for a position of longitude east or west. In all reports concerning navigational hazards and positions of lightships, buoys, and the like, transmitted over radio nets or published in the *Notice to Mariners*, position is given in detailed latitude and longitude.

Nautical Distance

On the Earth's surface, 1° of latitude is considered to be 60 miles in length, whereas the length of 1° of longitude varies with latitude. This is because parallels are always equidistant from one another, whereas

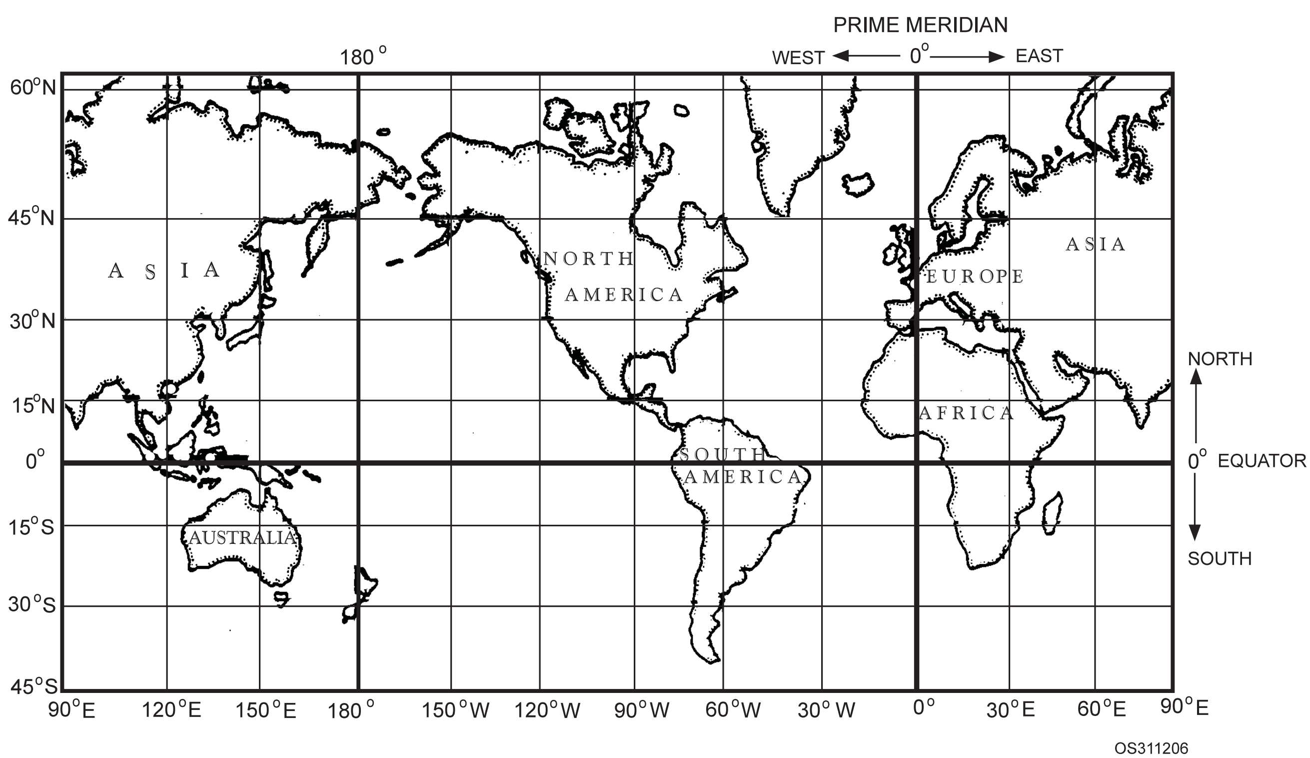


Figure 12-6.—Earth on the Mercator projection.

meridians converge at the poles. Hence, you must always use the latitude scale for measuring distance—NEVER use the longitude scale.

Distance is measured by placing one end of the dividers at each end of the line to be measured and, without changing the setting of the dividers, transferring them to the latitude scale with the middle of the dividers at about the middle latitude of the two points between which the distance is desired.

Scale of a Chart

The *scale* of a chart indicates the relationship between the size of a feature on the chart and the actual size of the feature on the Earth's surface. A chart's scale usually appears under its title in one of two ways: as a ratio or as a fraction. Consider the scale 1:1,200 (or 1/1,200). This particular scale indicates that 1 inch (foot, yard, etc.) on the chart represents 1,200 inches (feet, yards, etc.) on the ground. A scale of 1:14,000,000 indicates that 1 inch (foot, yard, etc.) on the chart represents 14,000,000 inches (feet, yards, etc.) on the ground.

You will hear charts referred to as "small scale" or "large scale". A small-scale chart covers a large area, whereas a large-scale chart covers a small area. This may seem confusing until you think of "scale" as a fraction. In the examples above, the fraction 1/1,200 is much larger than the fraction 1/14,000,000. So the 1:1,200 chart is a large-scale chart, while the 1:14,000,000 chart is a small-scale chart. The choice of scale depends on how much detail is required (See figure 12-7). Large-scale charts show many more details about an area than do small-scale charts. In fact, many features that appear on a large-scale chart do not show up at all on a small-scale chart of the same area. Normally, the major types of charts fall within the following scales:

1. Harbor charts: scales larger than 1:50,000. These charts are used in harbors, anchorage areas, and the smaller waterways. Charts drawn to these scales cover a smaller area than the next three types of charts, but they show many more features.
2. Coast charts: 1:50,000 to 1:150,000. These charts are used for inshore navigation, for entering bays and harbors of considerable width, and for navigating large inland waterways.

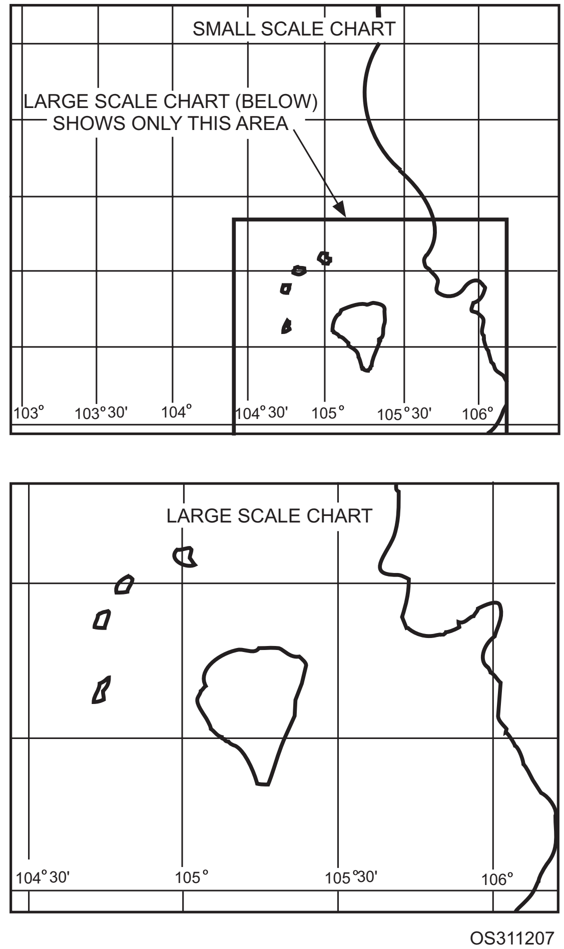


Figure 12-7.—Small-scale and large-scale charts.

3. General charts: 1:150,000 to 1:600,000. These charts are used for coastal navigation outside outlying reefs and shoals when the vessel is generally within sight of land or aids to navigation and its course can be directed by piloting techniques.
4. Sailing charts: 1:600,000 or smaller. These charts are used in fixing the ship's position as it approaches the coast from the open ocean, or for sailing between distant coastal ports.

When you work with small-scale charts, be sure to exercise greater caution than you would with larger scale charts. A small error, which may be only a matter of yards on a large-scale chart, could amount to miles on a small-scale chart. For navigating the approaches to land, you should use only large-scale charts.

Soundings

Scattered all over the watery area of any navigational chart are many tiny numbers, each representing the depth of the water (usually the depth

of mean low water) in that particular locality. Depths on charts are given in feet, fathoms, or meters. A notation under the title of the chart is the key; for example, "soundings in feet at mean low water" or "soundings in fathoms at…." Most charts also contain dotted lines used as depth curves to mark the limits of areas of certain depths. In figure 12-8, notice the numerous dotted lines along the shore that indicate depths of 5, 10, 15, and 20 feet and another line near where the Thimble Shoal channel and the bridge opening meet that indicates the 30-foot limit.

Aids To Navigation

Aids to navigation are indicated on a chart by appropriate symbols, shown in the numerous graphics comprising Chart No. 1, Nautical Chart Symbols and Abbreviations. As much information as possible is printed in standard abbreviations near the symbol. For instance, look at the Thimble Shoal light (teardrop symbol) at the western end of the Thimble Shoal channel in figure 12-8. Printed near the light is "Fl 10sec 55ft 12M HORN". This string of symbols tells us almost all that we need to know about the light.

1. *Fl* is the abbreviation for flashing. When a light is off for a longer period of time than it is on, it is said to be *flashing*. If it is on longer than it is off, it is said to be *occulting* (Occ). Lights can also be fixed (F), group flashing (Gp Fl), quick flashing (Qk Fl), and group occulting (Gp Occ). This list is by no means complete. You can find all of the types in the latest edition of Chart No. 1.
2. 10sec indicates the period of the light. That is, the time for the light to complete one full on-off cycle.
3. 55ft is the height of the light above mean high water.
4. 12M indicates that the light is visible, on a clear dark night, for 12 nautical miles.
5. HORN indicates that this light has a horn sound signal.

There are four standard colors for lights; red (R), green (G), yellow (Y), and white. Notice the channel in figure 12-8. The lighted buoys on the north side of the channel are labeled "Fl R 4sec", and the southern buoys, "Fl G 4sec", indicating the color of the lights. If there is no R, Y, or G symbol on the chart, the buoy light is assumed to be white.

The chart symbol for a buoy is a diamond shape. Notice that there is a small dot near every buoy symbol. That dot represents the buoy's approximate location. If the dot is enclosed in red, as are the channel buoys in figure 12-8, the buoy is lighted. The diamond shape is not actually drawn to scale and may be set down considerably off the buoy's actual position.

Q1. What is the major type of chart used in CIC?

Q2. How many meridians are contained in chart gridding?

Q3. On the Earth's surface, 1º of latitude is equal to how many miles?

GRID SYSTEMS

In CIC, three types of coordinates can be used to locate any given position: geographical, polar, and grid. You are familiar with geographical coordinates (latitude and longitude) and polar coordinates (range and bearing). We will now discuss grid coordinates.

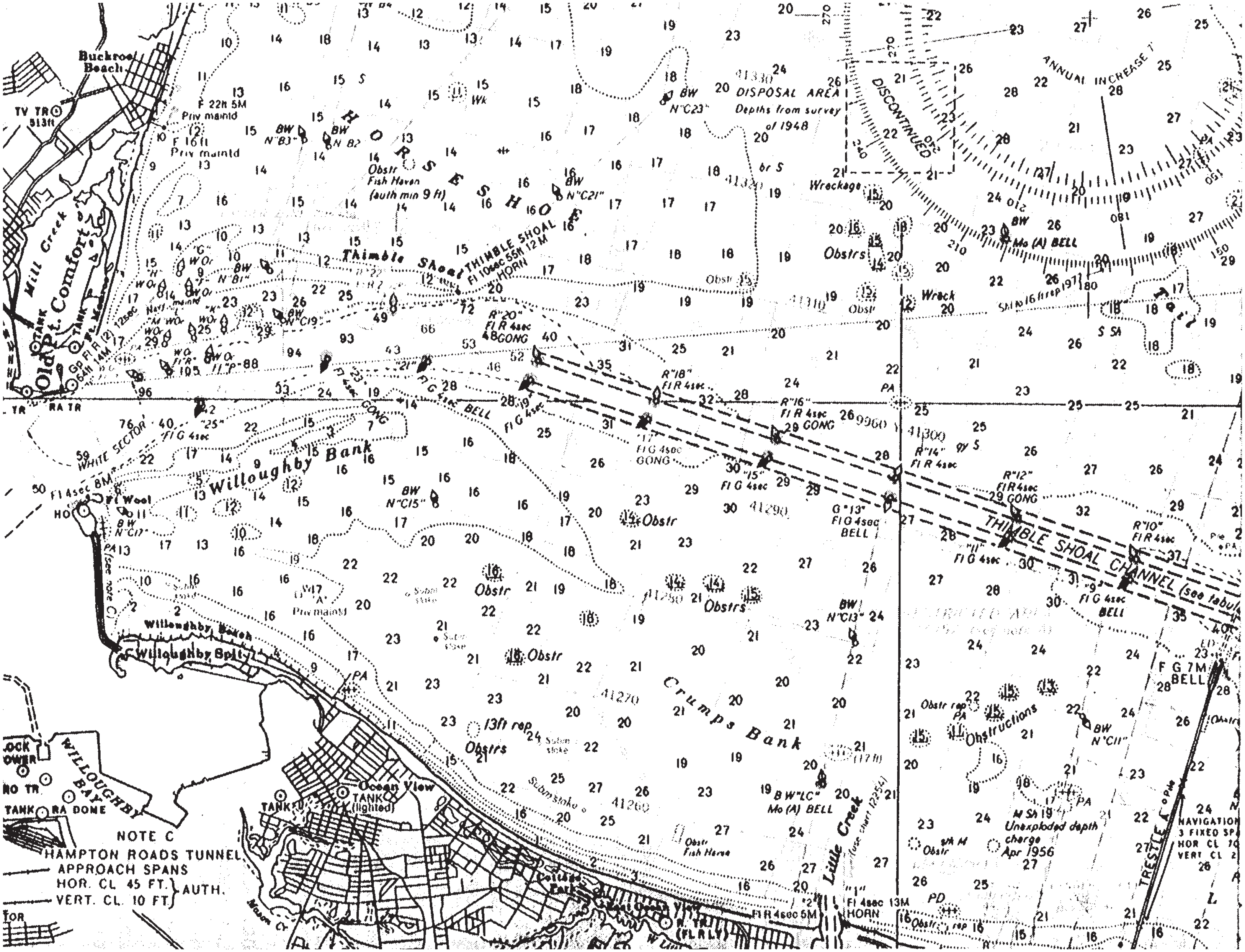
MAJOR GRIDS

Grid systems are used to simplify exchanges of positional information among ships, aircraft, and shore activities. These systems have special advantages in certain situations, by providing a rapid way to report positions. Basically, grids are lines drawn on a chart or vertical plot at right angles to each other. Some grids cover the entire globe, while others cover only a designated portion of the globe. Depending on the grid system used, the lines or the areas they represent are assigned number and letter titles or color codes.

On a grid, any point on the Earth's surface may be located by its grid reference. A grid reference never indicates more than one point, and the grid reference of a given point never changes unless the grid origin is changed. Own ship's position, course, and speed do not affect a fixed grid.

Three types of grids are in use in the Navy today: Cartesian coordinates, the world geographic reference (GEOREF) system, and the universal transverse Mercator grid (UTM).

The Cartesian coordinate grid system is used for position reporting in large-scale naval operations. This system is compatible with the naval tactical data system, and a single grid will include positions separated by hundreds of miles. The Cartesian system is the most widely used grid system within the Navy.



OS311208

Figure 12-8.—Part of NOS chart 12221.

The world geographic reference (GEOREF) system is a worldwide reporting system and is used for exchanging position information with the U.S. Air Force and some of our allies, using cross tell long-range communication circuits. As the name of the system suggests, a single grid covers the entire world.

The universal transverse Mercator (UTM) grid is used to increase reporting accuracy in localized military operations. For example, in shore bombardment operations, the position of an enemy gun emplacement can be pinpointed for naval gunners.

As an Operations Specialist, you must be familiar enough with each of these grid systems to be able to quickly convert a position from one system to another and from a grid position to polar or geographic coordinates.

Cartesian Coordinate (X-Y) Grid

The Cartesian coordinate (X-Y) grid system, as mentioned above, is used to support large-scale naval operations. It is not based on chart coordinates but is an additional grid superimposed over the charts for the area of operation. The Navy adopted the Cartesian system for use with the naval tactical data system (NTDS). Computers used in NTDS compute every position, in X-Y coordinates, in relation to a known reference point.

Positions transmitted from NTDS ships to conventional ships (on circuits such as link 14), have always been given in X-Y grid coordinates. This required conventional ships to convert the X-Y grid positions to coordinates in whatever grid system they were using.

To eliminate confusion and decrease the plotting delays created by using different systems, the Navy adopted the Cartesian coordinate grid as the standard grid for contact reporting, particularly in AW. Every ship now uses the Cartesian coordinate grid system.

The OTC establishes the center of the grid, which is called the *data link reference point* (DLRP). It may be given as a latitude and longitude or as a geographical landmark. Every position is then reported in relation to the DLRP.

The Cartesian coordinate grid contains four quadrants, each designated by a color (fig. 12-9): RED = northwest, WHITE = northeast, BLUE = southeast, GREEN = southwest.

Grid positions are indicated by a color followed by six numbers, such as Red 060 100. The color, of course, identifies the quadrant in which the numbers are located. The first three numbers are the X component and indicate the number of miles east or west (left or right) of the DLRP. In this case, since the color is red, the X component is 60 miles to the left (west) of the DLRP. The last three numbers are the Y component and indicate the number of miles north or south (up or down) from the DLRP. In this case the Y component is 100 miles up (north) of the DLRP.

Figure 12-9 shows a Cartesian grid superimposed on a vertical plotting board. The grid reference point is located 35 miles to the southwest of own ship. In the figure, the position of track number 201 at time 05 is Blue 070 075; bogey D-1 at time 04 is Green 060 060; track number 220 at time 05 is White 165 150; and track number 217 at time 04 is Red 005 110.

The plotters behind the board plot targets in polar coordinates (bearing and range) from own ship. The plotters in front of the board plot in Cartesian coordinates, since they are receiving Cartesian coordinate positions of targets from other ships. With this arrangement, anyone observing the plot can readily see a target's position in polar or Cartesian coordinates.

WORLD GEOGRAPHIC REFERENCE (GEOREF) SYSTEM

A system commonly referred to as a grid but which, in reality, is not a true military grid is GEOREF. A GEOREF is a simple and rapid method of expressing latitude and longitude. The GEOREF system enables any general position in the world to be located and is most valuable for use over large distances (primarily long-range air operations) or at great speeds.

The GEOREF system divides the Earth's surface into divisions and subdivisions. Its coordinates are read to the right and up.

This system divides the world into 15°-by-15° quadrangles. Beginning at the 180° meridian and proceeding eastward through 360° of arc, there are twenty-four 15° longitudinal zones. These zones are lettered A through Z, omitting I and O. Beginning at the South Pole and proceeding northward through 180° of arc, there are 12 latitudinal zones of 15° each. These zones are lettered A through M, omitting I. As you can see in figure 12-10, you can locate any of these 15° quadrangles with a two-letter designator by reading to

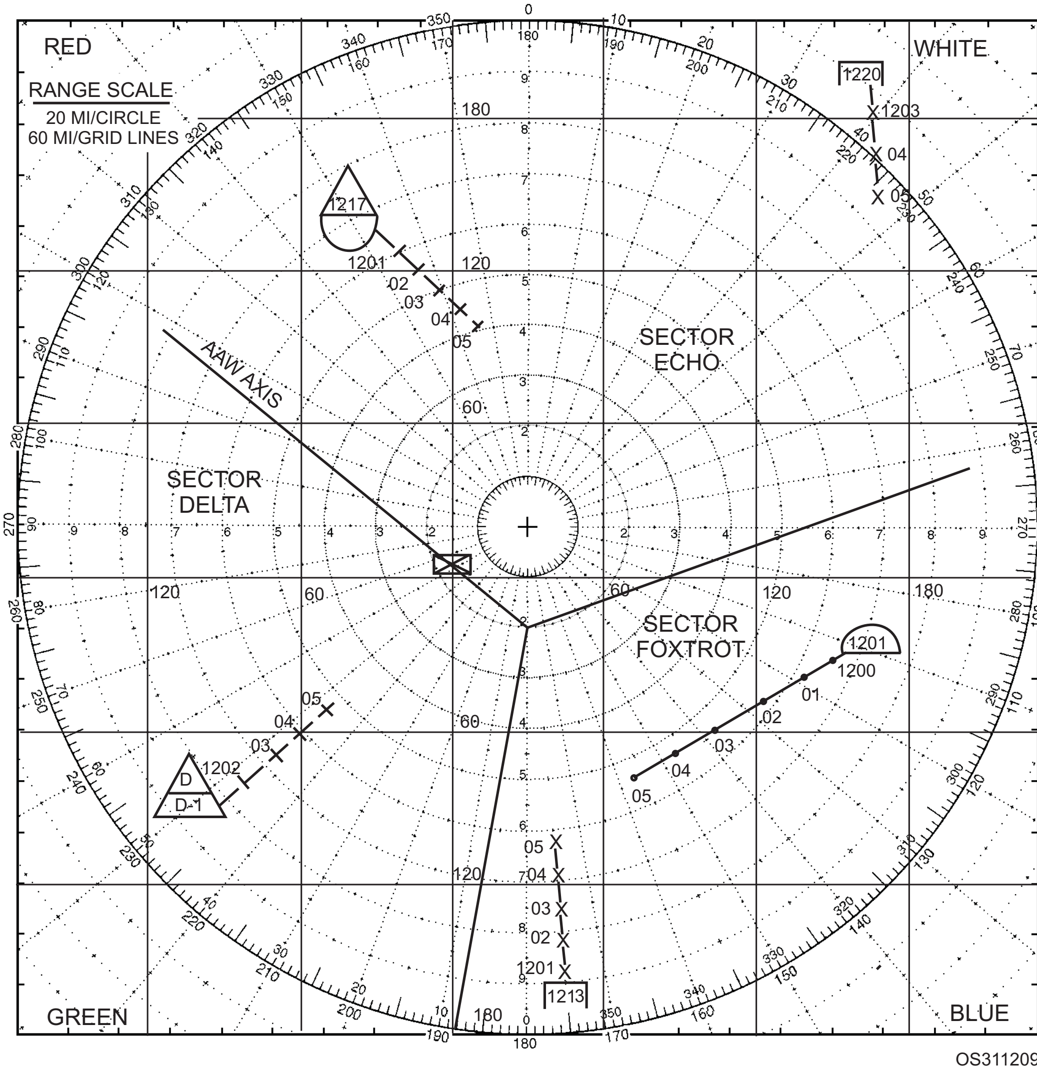


Figure 12-9.—Long-range vertical plotting board with Cartesian coordinate (X-Y) superimposed.

the right to the desired longitude (alphabetical column) then up to the desired latitude (alphabetical row).

Each 15° quadrangle is subdivided into 1° quadrangles. The 1° longitudinal zones are labeled A through Q, omitting I and O, beginning at the southwestern corner of the 15° quadrangle and heading eastward. The latitudinal zones are labeled similarly, heading northward from the southwest corner. This labeling system enables you to locate or designate any 1° quadrangle in the world by using its four-letter designator.

Each 1° area is further divided into 1-minute areas. The 1-minute areas are labeled numerically (from 00 to 59) from the southwest corner of the 1° quadrangle to the east and north. Thus, you can locate any geographical point on the Earth's surface to within an accuracy of 1 minute by using a four-letter and four-digit grid reference. (You can omit the two letters designating the 15° area if doing so will not cause confusion.).

NOTE

> To measure distance, always use the latitude (vertical) scale, in which 1 minute equals 1 mile.

To locate a point on the GEOREF grid, you must use a set procedure. For example, on a GEOREF chart, Patuxent Naval Air Station is located (to the nearest minute) at position GJPJ3716. In figure 12-10, the blacked-out square (PJ) within the enlarged 15° square (GJ) indicates the 1° area that contains Patuxent. To locate the position from the coordinates, proceed as follows:

Right from the 180° longitude to longitude zone G

Up from the South Pole to latitude zone J

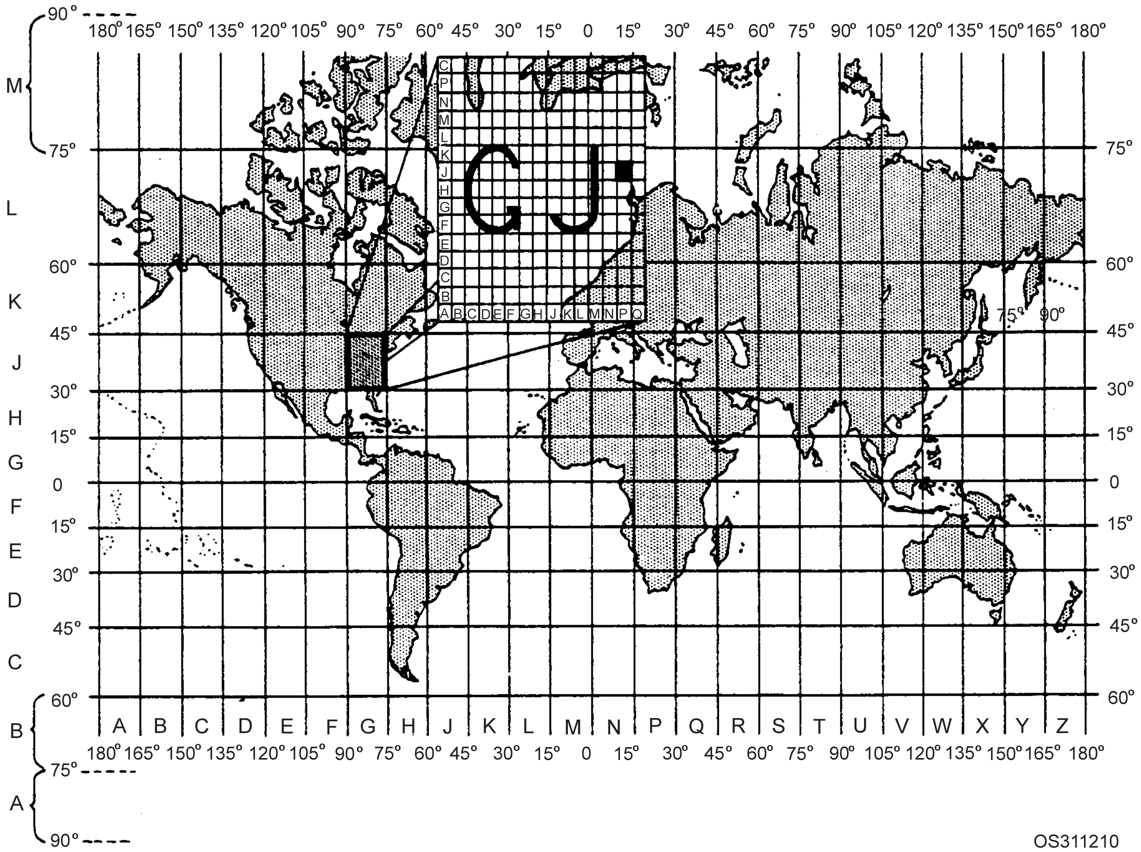


Figure 12-10.—GEOREF coverage of the world.

Right in zone GJ to the lettered 1° column P

Up in zone GJ to the lettered 1° row J

Right in the 1° horizontal zone to 37'

Up in the 1° vertical zone to 16'

The GEOREF system can also be used to designate a particular area around a reference point. This area designation follows GEOREF coordinates. The letter *S* denotes the sides of a rectangle; the letter *R*, the radius of a circle. Both dimensions are given in nautical miles. Another letter, *H*, also is used to denote altitude in thousands of feet. Figure 12-11 shows both area and point GEOREF positions.

Designation GJQJO207S6X6 means a rectangle centered around Deal Island 6 *nautical miles* on each side. Designation GJPJ4103R5 means a circle around Point Lookout with a radius of 5 nautical miles. Designation GJPJ3716Hl7 means a height of 17,000 feet over (fig. 12-11).

If a pilot were directed to make a rectangular search around Patuxent Naval Air Station, the signal for executing the search plan might be the following: GOLF JULIETT PAPA JULIETT THREE SEVEN ONE SIX SIERRA TWO ZERO XRAY ONE THREE HOTEL ONE SEVEN. Note that the length of sides is separated by the letter X.

GEOREF position designators should not be used for shore bombardment, close fire support, close air support, or for any other purpose where positional information must be reported with accuracy. The reason for this limitation is that these missions require position designations equivalent to small fractions of a second, while GEOREF designations are generally limited to minutes or, perhaps, seconds

CONVERTING POSITIONS

A ship's CIC functions best when target positions are maintained in the polar system (range and bearing). However, for this information to be sent to other units so that it can be used quickly and efficiently, it must be converted into position designators from another type of system, such as grid or geographical. Also, your ship may receive position information in one system that may need to be converted to another system before it can be used. Because of these requirements, you must be able to convert position information from one system to another.

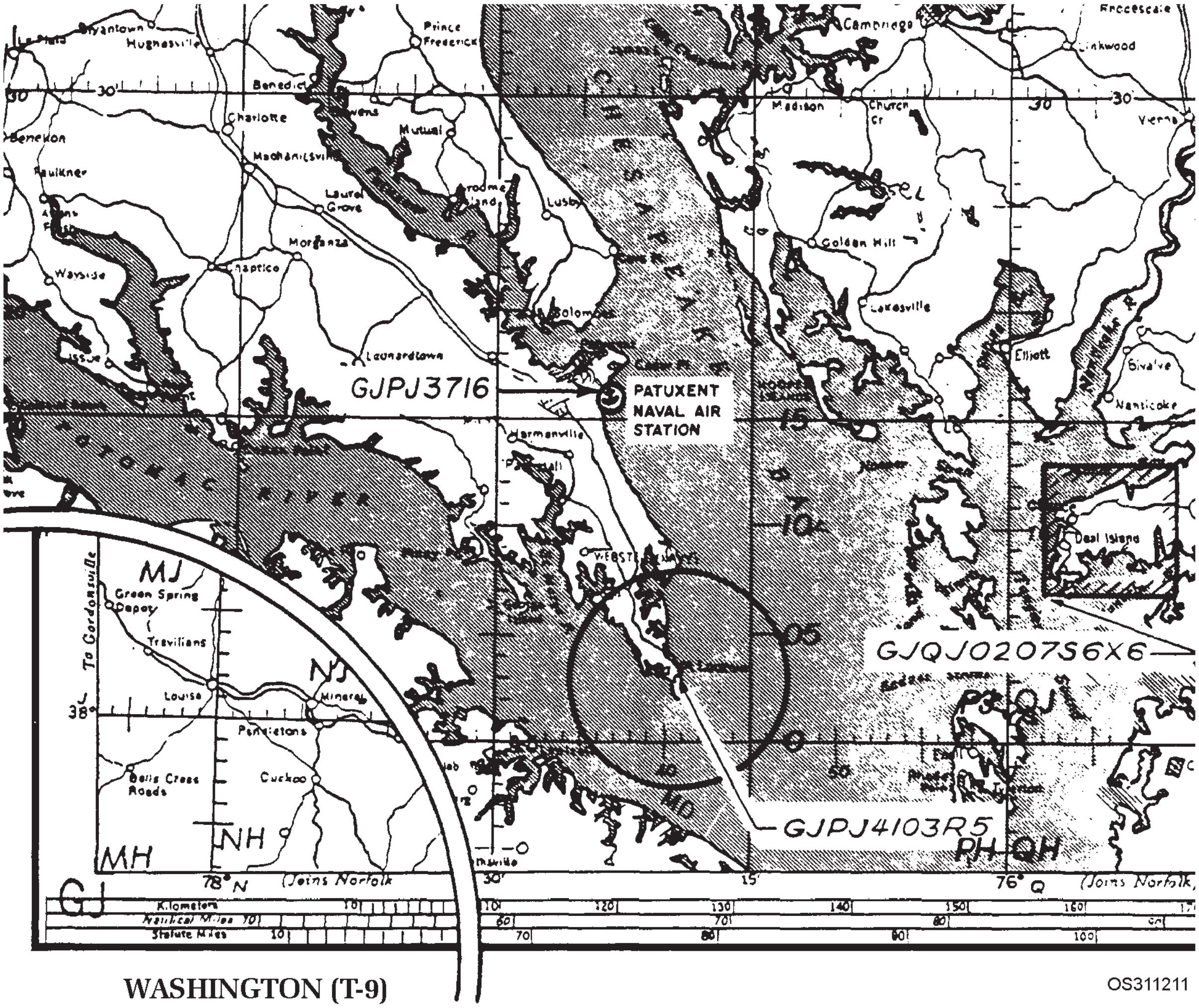


Figure 12-1l.—Point and area GEOREF designations.

GEOREF to Geographic Coordinates

The simplest conversion is from GEOREF to geographic coordinates, because GEOREF is only a geographic plot using letters and numbers instead of latitude and longitude. Every minute and degree of latitude and longitude has its own distinct GEOREF coordinates. Although charts are printed with GEOREF overlays, not all commands carry them in their chart portfolios. When charts are not carried on board, there is no hindrance in rapid plotting of a GEOREF position. The simplicity of this system makes it easy to plot a reference directly on a geographic presentation.

Assume that while a ship is steaming independently, it receives a message to proceed immediately to join an air-sea search for a downed aircraft last reported at a GEOREF position of HJDC3545. Speed is of the essence in this situation, so when a GEOREF chart is unavailable, a navigational chart of the area can be substituted. Some CICs maintain a folder showing world coverage of the GEOREF system. (This information is also provided in ATP l (C), Volume I, Chapter 2). Locate an illustration of the GEOREF grid superimposed over the Earth's surface (or look at figure 12-10) and find the 15° zone HJ. It is the zone with the southwest square at 75°W and 30°N. The second two letters represent single degrees east and north, respectively, from the southwest corner. Thus, HJDC represents the 1° square, the southwest corner of which is located at 72°W and 32°N, and the four numerals represent minutes of latitude and longitude. Hence, the GEOREF position indicated is 71°25'W, 32°45'N. As you can see, CIC can provide conn a position and recommendation in a comparatively short time.

Polar Coordinates to Grid Coordinates

Converting polar coordinates to grid coordinates requires the use of a conversion plot. A conversion plot

consists of a grid superimposed over a polar display (or vice versa). One type of conversion plot has a grid drawn on the back of a vertical plotting board, with the center of the grid located at the center of the plotting board, such as the one shown in figure 12-9. When this type of conversion plot is used, a plotter on the "polar" side of the board plots contacts in polar coordinates. Other personnel in CIC can then read grid positions of the plots directly from the "grid" side of the board.

When necessary, the DRT can be used in the conversion process. A grid or geographic overlay is aligned and then secured to the plotting surface. Internal plotting is done in the normal manner, with own ship's position indicated by the bug. Grid or geographic positions can then be read on the overlay. Any grid system of geographic significance must be readjusted periodically to compensate for motion caused by set and drift. The adjustment is made by moving the bug the required distance in a direction opposite the motion caused by set.

MILITARY GRID REFERENCE SYSTEM

The primary purpose of this system is to simplify and increase the accuracy of locating positions in military operations (shore bombardment, SAR missions in hostile areas, etc.). It may also be used to designate small areas of the Earth's surface for other purposes.

The military grid reference system divides the surface of the Earth into two grid systems: universal transverse Mercator (UTM) and universal polar stereographic (UPS). The universal transverse Mercator (UTM) grid covers all of the Earth's surface between latitudes 80°S and 84°N, while the universal polar stereographic (UPS) grid covers the areas from 84°N to the North Pole and from 80°S to the South Pole. The type of military coordinates a given position has depends on where that position is located. The majority of the Earth's surface falls within the UTM grid. Therefore, most positions of concern to us have UTM coordinates, and we will limit our discussion to the UTM system.

Universal Transverse Mercator (Grid

Earlier, we explained how a Mercator projection is made. A *transverse* Mercator projection is made in basically the same way, except that the transverse projection is rotated 90°. Instead of having the cylinder tangent to the Earth at the equator, the transverse projection has it tangent along a meridian. Creating a Mercator projection this way allows chart makers to superimpose a regular, rectangular grid on it. By dividing the surface of the Earth into a series of rectangles that are basically the same size, we can locate a position with extreme accuracy. You will have to locate given positions very accurately whenever you become involved in operations such as shore bombardment and SAR operations in hostile areas.

The UTM system provides the necessary accuracy by dividing and subdividing the Earth's surface into squares as small as 1,000 meters on a side. On a chart, you can break down each of these 1,000-meter squares into smaller squares and, if necessary, locate a position to within ±5 meters. Now, that's accuracy! Now, let's discuss the UTM grid itself, so you will know how to interpret a set of UTM coordinates.

In the UTM system, the Earth is first divided into 6° (east-west)-by-8° (north-south) areas called *grid zones* (See figure 12-12). In a north-south direction, the grid zones form *columns*. In an east-west direction, they form *rows*. Columns are numbered consecutively from 1 through 60, starting at the 180° meridian and proceeding eastward. Rows are lettered C through X (except for I and O), from latitude 80°S to latitude 84°N. The letters I and O are omitted to avoid confusion with numerals 1 and 0. This number-letter system provides each grid zone with a unique number-letter designator, called a *grid zone designation.*

You can determine the designation for any grid zone by reading right (columns), then up (rows) on the chart. Look at figure 12-12 and find grid zone "1Q". This grid zone is located at the intersection of column 1 and row Q. This grid zone is the only grid zone in the UTM grid that has the designation 1Q. The remainder of our discussion will be based on this grid zone, and the designation for every part of this grid zone will begin with "1Q".

Now notice the smaller areas on figure 12-12 designated by two letters. These are 100,000-meter (100,000 meters on each side) *grid squares* into which the grid zones are divided, for convenience in locating positions. To identify these squares, you also read right and up. In this case, though, columns are lettered from A through Z (with I and O omitted), starting at the 180° meridian and proceeding easterly along the equator, repeating every 18°. Rows are lettered from A through V (I and O omitted), with the lettering repeated every 2,000,000 meters (20 squares). The first letter is the column letter; the second letter is the row letter.

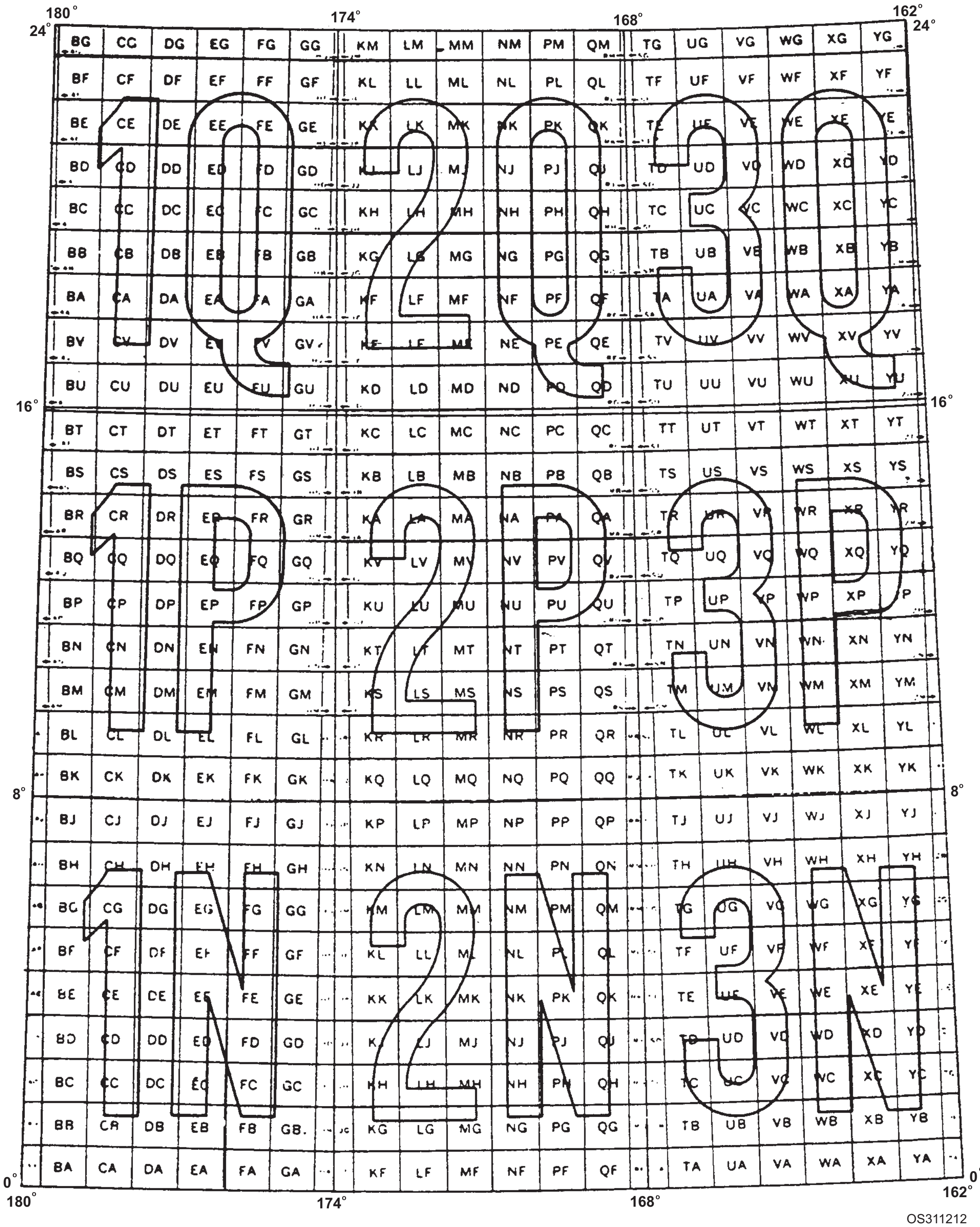


Figure 12-12.—Basic plan of the 100,000-meter square identification of the military grid reference system.

You can locate any 100,000-meter grid square on the UTM grid by using the designation of the grid zone in which it is located, plus the grid square's two-letter designation. For example, the 100,000-meter grid square "CU" immediately under the "1" in grid zone 1Q (fig. 12-12) has the grid designator "1QCU".

Ideally, each grid zone should be divided into equal numbers of 100,000-meter grid squares. Unfortunately, a 6°-wide zone cannot be divided into a whole number of 100,000-meter intervals; there is always a fraction of an interval left over. To minimize the "left over" area at the edge of a zone, the 100,000-meter columns are centered on the central

meridian of the zone. This splits the left over area, so that half of it lies on the western side of the zone and half on the eastern side of the zone. For uniform identification, these partial edge columns are included in the alphabetic progression of column labeling, even though they are not full-size blocks. Also, the number of columns in a grid zone decreases as the distance from the equator increases because the distance between meridians decreases from the equator toward the poles.

Now look carefully at the 100,000-meter grid square letter designators in figure 12-12. Notice that the designators along the equator between the 180° meridian and the 174° meridian end in the letter "A", while the designators between the 174° meridian and the 168° meridian end in the letter "F". The designators between the 168° meridian and the 162° meridian again end in the letter "A". This is an intentional offset in every other grid zone column and is done to help prevent confusion that might result from having the same 100,000-meter square designator reappear every 18°. All row designators within odd-numbered grid zone columns begin at the equator. All row designators within even-numbered grid zone columns are offset 500,000 meters south (The "A" squares are located five squares below the equator). This arrangement results in a shift of five letters between the 100,000-meter row designators of each grid zone column.

So far we have divided the surface of the Earth into 100,000-meter squares. View "A" of figure 12-13 shows 100,000-meter grid square 1QCU divided into one hundred 10,000-meter (10,000 meters on a side) grid squares, each designated by a two-digit number. The first digit is the column number; the second digit is the row number. Columns and rows are both numbered from 0 to 9. In view "A", read right to "6" and up to "5" and you will see the highlighted grid square "65". This 10,000-meter grid square has the grid designation 1QCU65. Finally, look at view "B" of figure 12-13. This illustration shows 10,000-meter grid square 1QCU65 divided into one hundred 1,000-meter grid squares. Each 1,000-meter grid square has a four-digit number, based on the grid square number "65". The second digit is the 1,000-meter grid square's column number (read right); the fourth digit is its row number (read up). Notice the shaded square. Its four-digit number is 6957. Therefore, the UTM grid designation of this particular 1,000-meter square is 1QCU6957. We have now divided the surface of the Earth into 1,000-meter squares.

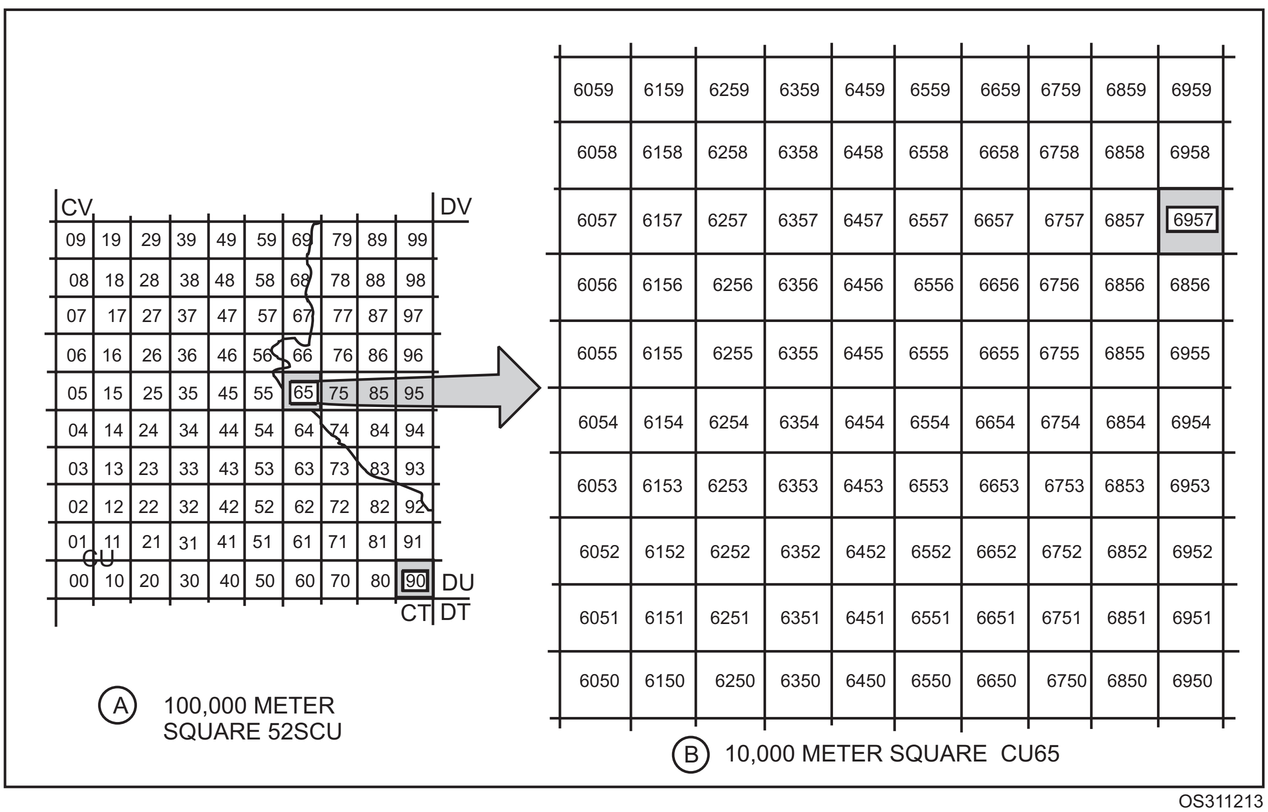


Figure 12-13.—A 100,000-meter grid broken down to provide 100-meter accuracy by expansion.

After all this chart work, what does the grid designation 1QCU6957 tell you? It tells you that this grid square is the 1,000-meter grid square "97", inside the 10,000-meter grid square "65", inside the 100,000-meter grid square "CU", inside grid zone "1Q". It also tells you that this 1,000-meter grid square encompasses an area 69,000 to 70,000 meters east of the southwest corner of 1QCU and 57,000 to 58,000 meters north of it. If you need to locate a specific target in this 1,000-meter grid square, simply divide it into 100- or 10-meter squares to get the accuracy that you need. Just be sure to add the appropriate additional grid numbers to the grid designation each time you subdivide the grid square. For example, a grid designation of 1QCU693578 identifies a 100-meter grid square inside grid zone 1Q, while 1QCU69315782 identifies a 10-meter grid square inside grid zone 1Q.

Thus, by using the UTM system, we have divided the surface of the Earth into easily identified squares only 10 meters on a side and have specifically identified 10-meter grid square 1QCU69315782. We can shoot a high-explosive round into this area, send a rescue helicopter to it to pick up a downed pilot, or any other job that we are tasked to do.

As in radar navigation, a conversion plot is used to convert UTM grid coordinates to bearings and ranges. Own ship's position is plotted on the "polar" side of the plot. As target positions come in, their grid coordinates are plotted on the "grid" side of the plot. Bearings and ranges from own ship to each target can then be determined very easily.

Q4. What are the three types of grid systems used by the Navy?

Q5. What grid reference system divides the world into 15º by 15º quadrangles?

NATIONAL IMAGERY AND MAPPING AGENCY (CATALOG OF MAPS, CHARTS, AND RELATED PRODUCTS)

Charts used in the Navy may be prepared by the National Imagery and Mapping Agency (NIMA), the National Ocean Service (NOS), the British Admiralty, or by other hydrographic agencies. Whatever the source, all charts used by the Navy are listed in the *National Imagery and Mapping Agency (NIMA) Catalog of Maps, Charts, and Related Products* and are issued by NIMA. The NIMA Office of Distribution Services has a network of small offices and branch offices located at military bases in the United States and overseas. Their locations, message addresses, and telephone numbers are listed in Part 2, volume I of the NIMA Catalog.

The *National Imagery and Mapping Agency (NIMA) Catalog of Maps, Charts, and Related Products* in is divided into the following seven parts:

- Part 1 - Aeronautical Products
- Part 2 - Hydrographic Products
- Part 3 - Topographic Products
- Part 4 - Target Material Products
- Part 5 - Submarine Navigation Products
- Part 6 - Special purpose/Crisis Catalogs
- Part 7 - Digital Data Products

HYDROGRAPHIC PRODUCTS

Part 2 of the NIMA catalog is the only part that you will normally use as an OS. It is a catalog of all hydrographic products (nautical charts and publications) and is divided into two volumes: Volume I (unclassified products) and Volume II (classified products). Volume I is organized into the following nine regions:

- Region 1 – United States and Canada
- Region 2 – Mexico, Central America, and Antarctica
- Region 3 – Western Europe, Iceland, Greenland, and the Arctic
- Region 4 – Scandinavia, Baltic, and Russia
- Region 5 – Western Africa, and the Mediterranean
- Region 6 – Indian Ocean
- Region 7 – Australia, Indonesia, and New Zealand
- Region 8 – Oceania
- Region 9 – East Asia

HYDROGRAPHIC BULLETINS

The Hydrographic Products Semiannual Bulletin Digest is published in April and October. It provides a complete listing of all available unclassified charts and

publications. You only need to keep the latest *Semiannual Bulletin Digest* to have current information on all available hydrographic products. Information appearing for the first time is marked with an asterisk.

Each of the hydrographic bulletins lists current editions of charts and publications, descriptions of all new charts, significantly changed new edition charts, and new publications and cancelled charts and publications. File these bulletins and use them to correct your catalogs. You can also use them to confirm that you hold the latest editions of charts and publications in your inventory and that you are not missing any chart from your required allowance.

NAUTICAL CHART NUMBERING SYSTEM

NIMA assigns a number to every nautical chart used by the U.S. Navy, regardless of the organization or government producing the chart. NIMA charts have numbers consisting of one to five digits. The number of digits generally indicates the scale range, and the number itself indicates the geographical area covered by the chart. The chart numbering system is as follows:

1. One-digit number (1-9) — This category consists of charts that have no scale connotation, such as symbol and flag charts.

2. Two- and three-digit numbers (10-999) — This category includes small-scale, general charts that depict a major portion of an ocean basin, with the first digit identifying the ocean basin. The first digit denotes the ocean basin containing the area covered by the chart (See figure 12-14). For example, Chart No. 15 covers the North Atlantic Ocean (northern sheet). Two-digit numbers (10-99) are used for charts having a scale of 1:9,000,000 and smaller, including world charts, while three-digit numbers (100-999) are used for charts having a scale between 1:2,000,000 and 1:9,000,000.

3. Four-digit numbers (5000-9999) — This category includes great circle tracking charts, electronic navigation system plotting charts, and special-purpose non-navigational charts and diagrams. Four-digit charts with a letter prefix (EOIOI-E8614) are bottom contour charts.

4. Five-digit numbers (11000-99999) — This category includes all standard nautical charts having a scale larger than 1:2,000,000 (large and medium scale). At scales such as this, the charts cover portions of the coastline rather than significant portions of ocean basins. The majority of the charts listed in Part 2, Volume I are five-digit charts and are based on the nine regions of the world shown in figure 12-15. The first of the five digits indicates the region to which the chart belongs. The first and second digits together indicate the geographic sub-region within the region, and the last three digits identify the geographic order of the chart within the sub-region.

5. Six-digit numbers (800000-809999) — This category consists of combat charts and combat training charts. A random numbering system is used to prevent the identification of the geographical area covered by a classified combat chart without referring to the catalog. One reason for this is to allow you to order classified combat charts with an unclassified requisition. Also included in the six-digit numbering system are mine warfare planning charts (MCMCH810000-819999). These charts show predetermined passages into and out of large ports that have been searched for any mine-like objects (Q Routes). They may also contain environmental information for selected areas. Like combat charts, these classified charts use a random numbering system to prevent the identification of the geographical area.

PORTFOLIO DESIGNATIONS

The U.S. Navy uses three portfolio (grouping) systems to assign charts into allowances for ships. These portfolio systems are Standard Nautical Charts, World and Miscellaneous Charts, and Bottom Contour Charts. Except for certain bottom contour charts, the letter in the third position of the NIMA stock number is the portfolio assignment letter. Portfolio designators are recommended by NIMA and approved by the fleet commander in whose area of responsibility the charts lie.

Standard Nautical Charts

Most standard nautical charts are assigned to either an “A” portfolio or a “B” portfolio.

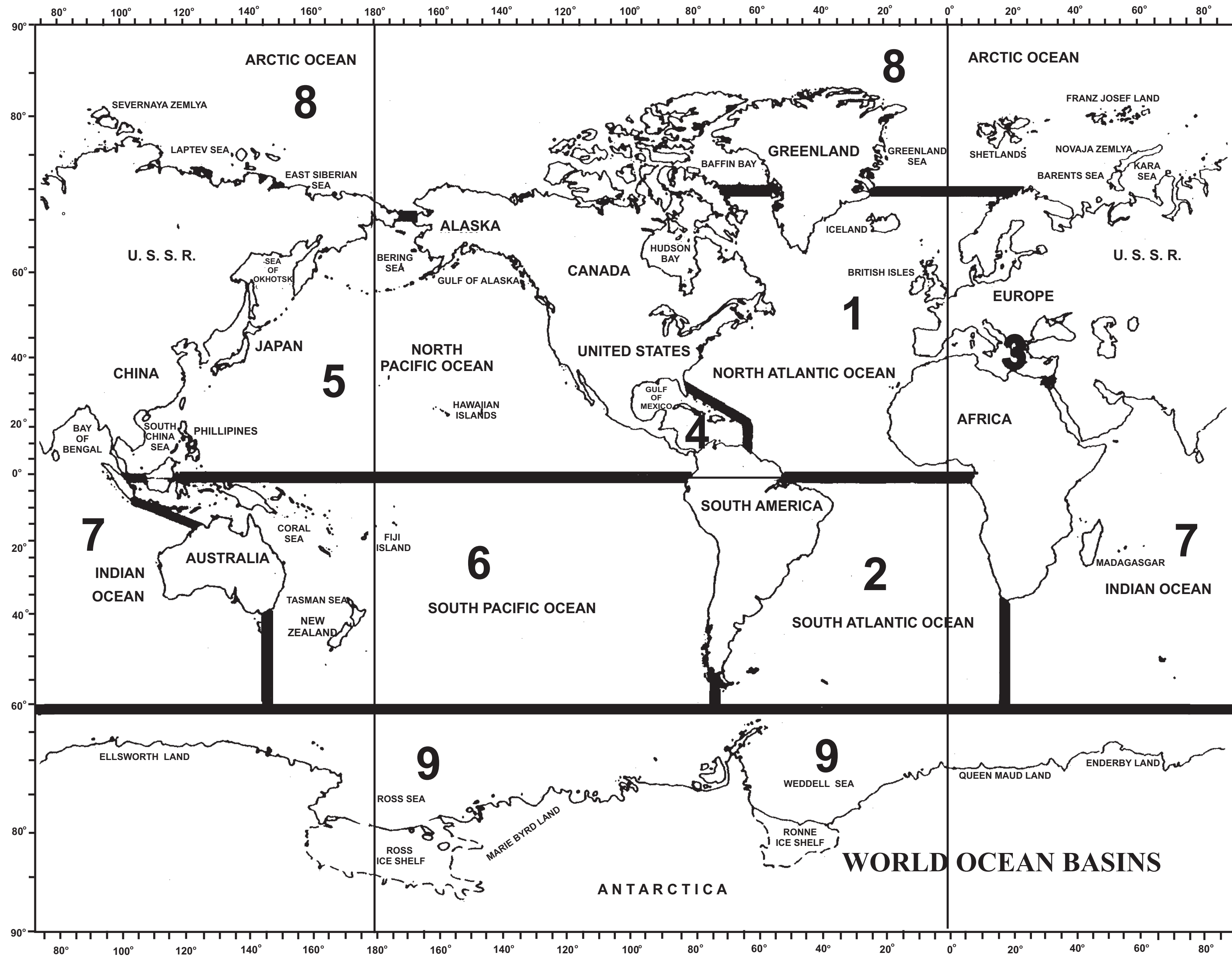


Figure 12-14.—World ocean basins.

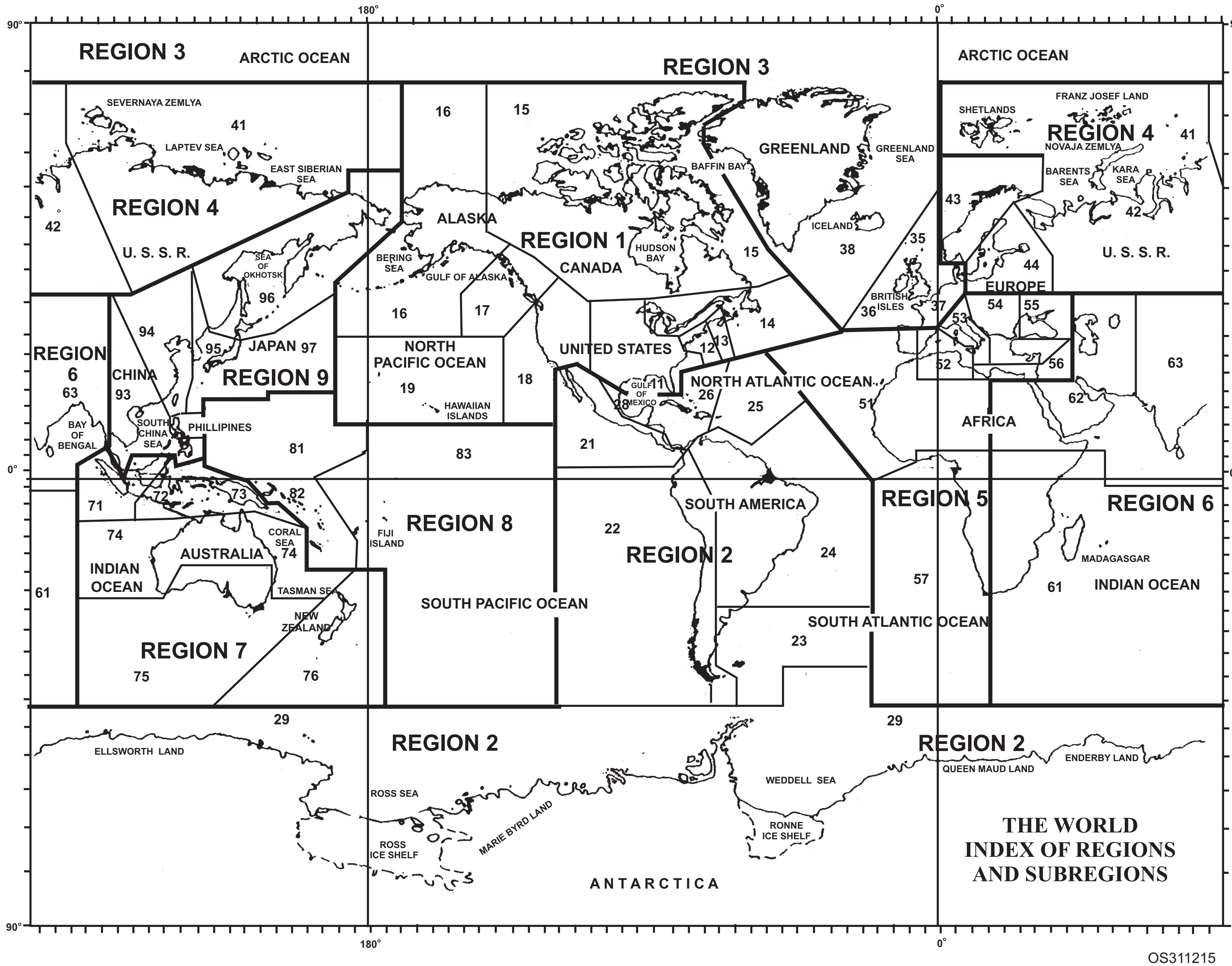


Figure 12-15.—World regions.

"A" portfolios consist of operating area charts and principal coastal and harbor and approach charts for each sub-region.

"B" portfolios supplement "A" portfolios with additional coastal and harbor and approach charts for each sub-region.

Standard nautical charts that are not assigned to a portfolio have an "X" in the third position of the NIMA stock number.

A standard nautical chart portfolio is commonly referred to by use of a sub-region number with the portfolio designation letter, e.g., Portfolio 14A.

World and Miscellaneous Charts

Most world and miscellaneous charts are assigned to either an "A" portfolio or a "P" portfolio.

"A" designates Atlantic Ocean charts.

"P" designates Pacific Ocean charts.

"B" designates other ocean regions or charts that cannot be categorized by a specific geographic region. While "X" designates charts not in a portfolio.

A world nautical chart portfolio is commonly referred to by use of the first two letters (WO) of the NIMA stock number, with the portfolio designation letter, e.g., Pacific Ocean Portfolio, WOP.

Bottom Contour Charts

Bottom chart portfolios are designated by the area they cover.

"EP" in the second and third positions of the NIMA stock number designates the Eastern Pacific Ocean.

"WP" in the second and third positions designates the Western Pacific Ocean.

"IN" in the second and third positions designates Indian Ocean.

"X" in the third position designates Atlantic Ocean.

ARRANGEMENT OF CHARTS

Charts are arranged and numbered in a geographical sequence, which permits systematic stowage aboard ship. Within each region, the geographical sub-regions are numbered (first two digits of the five-digit chart number) counterclockwise around the continents; within each sub-region, the individual charts are numbered (last three digits of the five-digit chart number) counterclockwise around the coasts. Many numbers are left unused so that charts produced in the future may be placed proper sequence.

NIMA STOCK NUMBERING SYSTEM

A five-digit alphanumeric series designator prefix is assigned to each standard nautical chart number (fig. 12-16). The purpose of this prefix is to speed up processing and to improve inventory management by the NIMA.

The first two digits of the prefix reflect the geographical sub-region, as do the first two digits of the basic chart number. The third position is the portfolio assignment, "A" or "B". The letter "X" is used if the chart is not included in a portfolio. The fourth and fifth positions are alphabetical designators for the type of chart. Examples of the designators are "HA" for harbor and approach charts and "OA" for operating area charts. When you order charts, be sure to use the complete NIMA stock number.

Q6. What part of the NIMA catalog lists all hydrographic products that you will use in CIC?

Q7. The Hydrographic Products Semiannual Bulletin Digest is published during what months?

CHART/PUBLICATION CORRECTION RECORD CARD SYSTEM

To be useful, a chart must be accurate. When a chart is first issued, it is known as a *new chart*, or *first edition*. New charts are considered to be accurate, as printed, until changes are issued. Over a period of time, many changes may be issued for a particular chart. When the changes become too numerous or when new information is too extensive to be issued through the *Notice to Mariners*, a version of the chart that includes all accumulated changes is printed and issued. This changed version is known as a *new edition*. When a new edition of a chart is issued, the previous edition automatically becomes obsolete and must be destroyed.

The number of charts carried aboard ships and the frequency with which charts change, dictate that some system be used to track changes and to keep the charts up-to-date. The system currently being used throughout the fleet is the Chart/Publication Correction Record Card System.

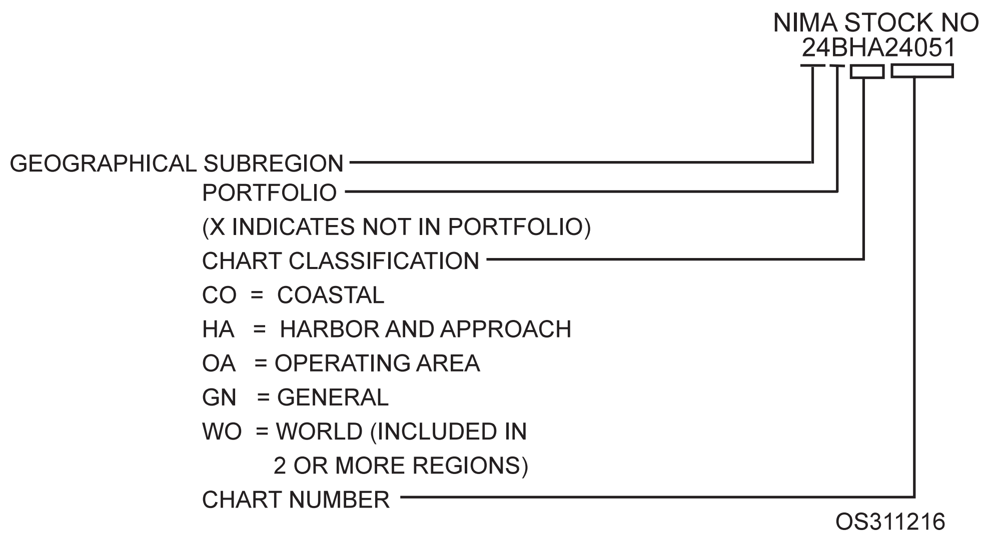


Figure 12-16.—NIMA stock number.

NOTICE TO MARINERS

The chart and publication correction system is based on the periodical *Notice to Mariners*, published weekly by the NIMA to inform mariners of corrections to nautical charts and publications. This periodical announces new nautical charts and publications, new editions, cancellations, and changes to nautical charts and publications. It also summarizes events of the week as they affect shipping, advises mariners of special warnings or items of general maritime interest, and includes selected accounts of unusual phenomena observed at sea. Distribution of the *Notice to Mariners* is made weekly to all U.S. Navy and Coast Guard ships and to most ships of the merchant marine.

The classified Chart and Publication Correction System is based on the *Classified Notice to Mariners*, published on an as-needed basis by the NIMA to inform mariners of corrections to classified nautical charts and publications.

The *Notice to Mariners* provides information specifically intended for updating the latest editions of nautical charts and publications issued by NIMA, the National Ocean Service, and the U.S. Coast Guard. When you receive the *Notice to Mariners*, examine it for information of immediate value. To minimize record keeping, record the notice's edition and date on the Chart Publication Correction Record Card of each chart and publication affected by that notice. Also check the list of new charts and new editions of charts and publications to assure that you have the latest editions on board.

In section I of the *Notice to Mariners*, you will find chart corrections listed by chart number, beginning with the lowest and progressing in sequence through each chart affected. The chart corrections are followed by publication corrections, which are also listed in numerical sequence. Since each correction pertains to a single chart or publication, the action specified applies to that particular chart or publication only. If the same correction also applies to other charts and publications, it is listed separately for each one.

Figure 12-17 illustrates the *Notice to Mariners* format for presenting corrective information affecting charts. A correction preceded by a star indicates that it is based on original U.S. source information. If nothing precedes the correction, the information was derived from some other source. The letter T preceding the correction indicates that the information is temporary; the letter P indicates that it is preliminary. Courses and bearings are given in degrees clockwise from 000°true.

SUMMARY OF CORRECTIONS

The *Summary of Corrections* is a five-volume cumulative summary of corrections to charts and publications previously published in *Notice to Mariners* NIMA publishes each of the five unclassified volumes semiannually and the classified volume annually. The *Summary of Corrections* is organized as follows:

- Volume I — East Coast of North and South America
- Volume II — Eastern Atlantic and Arctic Oceans, including the Mediterranean Sea

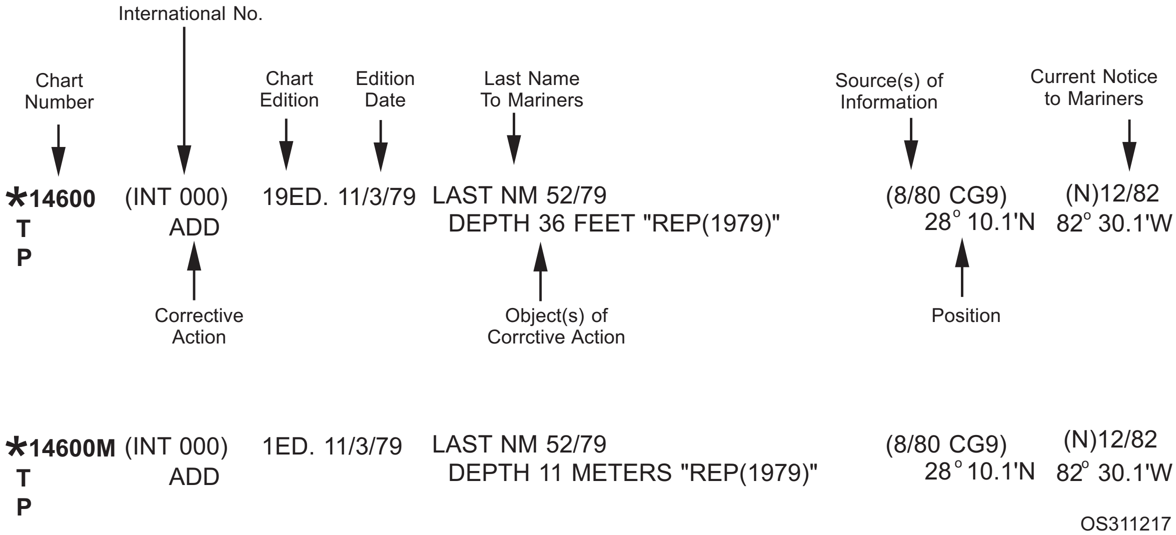


Figure 12-17.—Exerpt from a weekly Notice to Mariners.

- Volume III — Eastern Pacific, Antarctica, Indian Ocean, And Australia
- Volume IV — Western Pacific Ocean
- Volume V — World and Ocean Basin Charts, U.S. Pilots, Sailing Directions, Fleet Guides, and other publications

CHART/PUBLICATION CORRECTION RECORD CARD

The Chart/Publication Correction Record Card (NIMA Form No. 8660/9), shown in figure 12-18, is used to indicate that corrections to a chart or publication have been published in a *Notice to Mariners* and to show when the corrections were made. Normally, one card is kept for each NIMA chart and publication kept on board, but command may direct that cards also be kept for other charts and publications. Within this system, only the charts and publications of the immediate operating area need to be corrected. Charts and publications not currently needed may be updated as areas of operations change or as directed by the commanding officer.

ESTABLISHING THE CORRECTION RECORD CARD SYSTEM

If your ship does not have a Chart/Publication Correction Record Card System, you may create one. Using Part 2 of *NIMA Catalog of Maps, Charts, and Related Products,* prepare a card for each NIMA chart and publication carried on board, inserting the following information:

1. Chart/publication number.
2. Edition number/date.
3. Classification.
4. Latest *Notice to Mariners* through which the chart is corrected.
5. Title. (Abbreviate long titles as necessary.)

MAINTAINING THE CORRECTION RECORD CARD SYSTEM

To maintain the record card system, use the following procedure:

1. When you receive a new *Notice to Mariners,* check it to see which charts or publications need correcting. If any of the charts or publications that your ship holds require correcting, pull their associated correction record cards. On each card, record the number and year of the *Notice to Mariners*.
2. If any of the corrections that you need to record are identified in the *Notice to Mariners* as “preliminary” or “temporary”, identify them on the correction record card with a “P” or a “T”.
3. After you have entered the *Notice to Mariners* number and year on the cards, plot the specified corrections on the charts that are in active use (or on the charts specified by your commanding officer). After you make the correction(s) to a chart, enter on the chart’s correction record card the date that you made the correction(s) and initial the card.

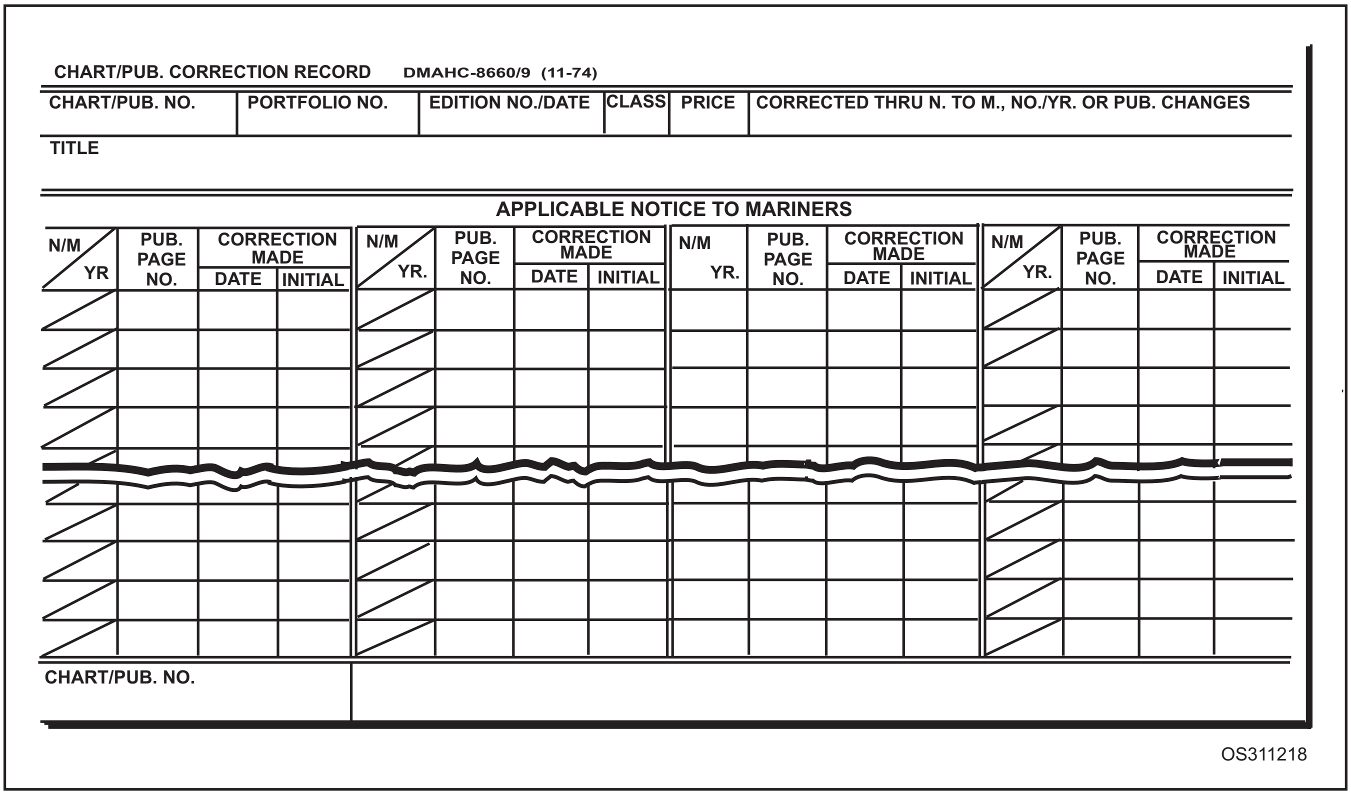


Figure 12-18.—Chart/Publication Correction Record Card.

NOTE

In correcting charts that have accumulated numerous corrections, make the latest correction first and work backwards, since later corrections may cancel or alter earlier corrections.

4. When you receive a new chart or a new edition of a chart, make a new card your system will reflect only the corrections (including temporary changes) that have been published since the date the new or corrected chart was published. Carry forward temporary corrections, since they are not incorporated into new editions of charts.

5. If your ship carries more than one copy of a particular chart, you only need to maintain one record card for that group. However, to preclude omitting a correction on one of the charts, correct all of the copies at the same time.

AVIATION CHARTS

All naval air stations, facilities, and aircraft-capable ships keep a permanent file of aviation charts and publications for the areas in which their aircraft may need to operate. If your ship is required to keep aviation charts, refer to *Part 1, Aerospace Products*, of the NIMA *Catalog of Maps, Charts, and Related Products* for ordering and maintenance information. Use the same procedures to keep these charts and publications up-to-date as you do nautical charts and publications (for specifics, refer to aeronautical product bulletins and the *Aeronautical Chart Updating Manual*.

CHART ORDERING PROCEDURE

When a ship is first commissioned, NIMA outfits it with its initial allowance of charts and publications. Your ship will receive new and revised charts and publications through the Automatic Initial Distribution (AID) System.

SHIP ALLOWANCE

The basic load of maps, charts, and publications your ship is required to hold is prescribed in allowance instructions issued by your fleet commander or type commander. In some cases a ship may have its basic allowance supplemented by another allowance that covers the area to which the ship deploys. In these cases, your type commander will normally request your deployment allowance about 3 months before your deployment. You should become familiar with

the allowance instructions that pertain to your ship, as you may be required to help maintain that allowance.

During normal operations, some charts will be worn out, while others will be required in greater quantities than were in the original issue. To order replacement charts and additional charts, submit your requisitions, using MILSTRIP ordering procedures, via the Defense Automatic Addressing System (DAPS). You can find specific ordering instructions in the Ordering Procedures section of NIMA *Catalog of Maps, Charts, and Related Products, Part 2-Volume I.*

AUTOMATIC INITIAL DISTRIBUTION

Automatic Initial Distribution (AID) refers to the automatic issue of predetermined quantities of new or revised products. AID is the means by which your ship's allowances of charts and publications is kept current with no requisitioning action required on your part. Annually, the NIMAODS forwards to each U.S. Navy ship on AID a computer listing, called AID Requirements for Customer Report (R-05), to allow the command to confirm its allowance holdings.

CLASSIFIED CHARTS AND PUBLICATIONS

Your ship will undoubtedly have some classified charts and publications on board. These charts and publications must be handled and stored according to the requirements of the *Department of the Navy Information Security Program Regulation*, SECNAVINST 5510.36. The following basic provisions apply to the handling and storing of these materials.

1. Only persons with the necessary security clearance and a definite need to know should be granted access to the information.
2. When classified material is not under the direct observation of an authorized person, it must be locked up or given equivalent protection.
3. Charts must be stored in locked drawers. Publications must be stored in locked safes or cabinets.
4. Money, jewels, or other valuables must never be stored in containers used for storing classified material.
5. Combinations (or keys) to safes or locks must be accessible only to persons whose official duties require access to the material in the containers.

Q8. What weekly NIMA publication contains all corrections for nautical charts and publications?

NAVIGATION

Navigation is the means by which a navigator determines the ship's position and guides the ship safely from one point to another. Operations Specialists, as members of the CIC team, assist the navigator in determining the ship's position. Positions in navigation may be determined in the following four ways:

1. By piloting. — Position is determined through the aid of visual ranges and bearings to objects on the Earth and by soundings (measuring the depth of water by lead line or depth sounder).
2. By dead reckoning. — Position is figured by advancing a known direction and distance traveled from a known point of departure.
3. By electronics. — Position is determined by loran, Omega, satellite, radar, and other electronic devices. Electronic navigation, in some instances, overlaps piloting.
4. By celestial navigation. — Position is determined with the aid of celestial bodies (the sun, moon, planets, and stars).

The remainder of this chapter explains the assistance CIC provides to the navigator, such as informing conn concerning the ship's position, interpreting Rules of the Road, station-keeping, and making recommendations for maneuvering.

PILOTING

Piloting is a highly accurate form of navigation involving frequent determination of a ship's position relative to geographic references. When a ship is operating near land or when other visual aids to navigation are available, piloting is used to prevent mishaps. This method of navigation requires good judgment, constant attention, and alertness on the part of the navigator.

When a ship is moving into or out of a harbor, close to islands, reefs, or coastlines, the navigator pinpoints the position of the ship by plotting visual bearings received from a Quartermaster. The Quartermaster, stationed at the pelorus, takes bearings from visible

objects such as tanks, radio towers, lighthouses, points on shore, or other aids to navigation. By plotting successive fixes on a chart showing true positions of reference points from which bearings are taken, the navigator maintains a true track of the ship. Observations of these fixes and DR tracks of the ship enable the navigator to make recommendations to the officer of the deck concerning the course the ship should follow to reach its destination safely.

The fact that a position is determined by bearings taken on visual objects implies that a ship being piloted is in restricted—often dangerous—waters. In the open sea, there may be ample time to discover and correct an error. In restricted waters, an error can quickly cause an accident. To reduce the possibility of error to a minimum, Operations Specialists provide backup information for the navigator.

Functions Of in Piloting

One of the ways CIC assists the navigator and the officer of the deck in piloting is to plot radar fixes to create a backup plot of the ship's position. Radar gives an excellent picture of coastlines, harbors, channels, buoys, and other objects. In addition to radar, CIC also uses underwater search equipment and depth sounding equipment.

Radar navigation places great demands upon plotters and radar operators. Thus, it requires practice at every opportunity. In good visibility, the CIC piloting team can gain experience and aid the navigator at the same time. By developing a radar plot, CIC provides the navigator a ship's position to compare with the position developed from visual sightings. The two positions should be identical. If they differ, the navigator will take the time necessary to determine the ship's actual position. An additional benefit of having CIC develop a radar plot during piloting is that if visibility suddenly drops so that the Quartermaster can no longer take sightings, the navigator will have a backup plot to use in navigating the ship.

The accuracy of the radar plot is dictated by the circumstances at the time the plot is made. Many functions of the ship, such as shore bombardment and amphibious operations, depend on accurate knowledge of ship's position.

Navigational Plot

When the ship is near land, Operations Specialists must maintain a continuous navigational plot for the following reasons:

1. To warn the bridge the moment the ship begins to stand into danger
2. To supply radar information on short notice to the navigator and conning officer, as requested
3. To aid in identifying enemy targets
4. To provide gun ranges and bearings for indirect fire shore bombardment
5. To assist in directing boat waves during landing operations
6. To navigate the ship from radar information, if ordered
7. To assist in making landfalls and to identify land masses
8. To assist landing ships and craft in their beach approach

One important point you must remember whenever you plot on a chart is to use the correct colors in marking the chart. While color doesn't matter much on charts that are marked in daylight or in normally lighted areas, it matters greatly in blacked-out areas. Recall times that you entered darkened areas. For the first few minutes, you could not see your surroundings. Gradually, however, you began to make out shapes. During that brief period, your night vision was taking over from your day vision. Night vision sensors in your eyes are very sensitive to white light and can be instantly overwhelmed by it. These same sensors, though, work very well in areas lighted by red light. This is why areas that require low light are frequently lighted by red lights. So what is the problem with colors on charts? Under red light, the colors buff, orange, and red are invisible. You will not be able to see anything printed or written on a chart in these colors. The NIMA has met this situation by using gray, magenta, purple, and blue on the charts. These colors appear as different shades, not as different colors, under red light. Be very careful in using old charts under a red light. If any vital features or markings are shown on the charts in red, orange, and yellow colors, redraw them in some color that will show, such as blue, green, brown, or purple. And when you draw on a chart in daylight, do not use a red marker. If you do and later have to use the chart under a red light, you will not be able to see any of your marks.

Tactical Data

Every ship has specific maneuvering characteristics known as the *ship's tactical data*.

These data are determined by the navigation department and are available on the bridge, in CIC, and in the engine room. Two of the maneuvering characteristics, advance and transfer, are extremely important in plotting a dead-reckoned track in radar piloting and also in tactical maneuvers. The ship's tactical data consist of the following information:

1. Acceleration — The rate of increase in ship's speed.
2. Deceleration — The rate of decrease in speed.
3. Acceleration/deceleration distance — The distance covered between the point where an increase or a decrease in speed is ordered and the point where the ship is steady on the new speed.
4. Advance — The distance gained in the direction of the original course when the ship is turning. See figure 12-19. It is measured in the direction of the original course from the point where the rudder is first put over. The advance will be at maximum when the ship has turned 90°. If the turn is less than 90°, it is measured to the point where the ship is steadied on the new course.
5. Transfer. — The distance gained at right angles to the original course when the ship is turning, to the point of completion of the turn. See figure 12-19.
6. Tactical diameter. — The distance gained to the right or left of the original course when a turn of 180° has been completed, when constant rudder angle is used. Figure 12-19 illustrates that the tactical diameter is the transfer for a turn of 180°.
7. Final diameter: The diameter of the turning path of the ship when it has completed 360° of steady turning.
8. Standard rudder. — The amount (in degrees) of rudder that will turn a ship on the turning circle of a prescribed standard tactical diameter.

Use of Tactical Data

As we mentioned earlier, a folder containing the ship's tactical characteristics is kept on the bridge, in CIC, and in the engine room. Usually this folder contains the following tables:

1. The number of revolutions per minute necessary to make desired speeds. This information is posted also at the annunciators and the throttles.
2. Time versus distance the ship will continue until no forward motion is evident when the engines are stopped at 5, 10, and 15 knots.
3. Time versus distance required to stop the ship when the engines are backed one-third, two-thirds, and full speed while the ship is steaming ahead at normal speed.
4. Time required to turn 45°, 90°, 135°, and 180°, using normal, stationing, and operational speeds for rudder angles of 10°, 15°, and 25° and full rudder.
5. Time versus reach-ahead (acceleration distance) in accelerating from normal speed to stationing and operational speeds.
6. Number of yards from station at which speed should be dropped to formation speed in order to coast into station.
7. Diagrams of turning circles, showing the tactical diameter for 180° and transfer for 90° for rudder angles of 10°, 15°, 20°, 25°, and full rudder at speeds of 10, 15, 20, and 25 knots (or as many of these speeds as the ship can make).

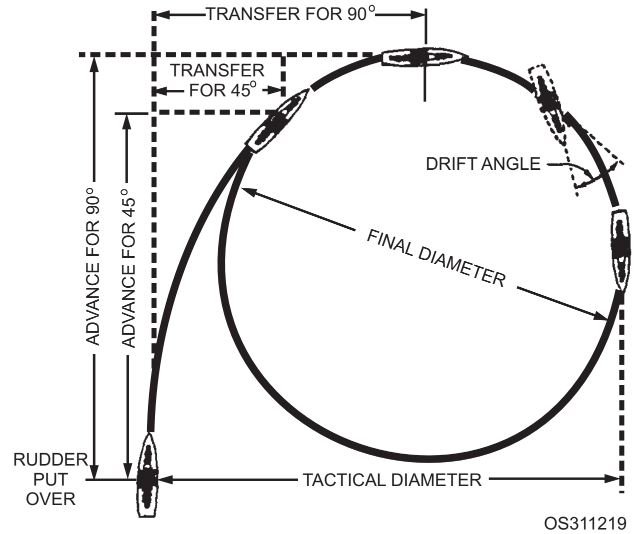


Figure 12-19.—Ship turning circle.

Table 12-1 shows sample turning characteristics of a ship. (These figures are for example purposes only. When you plot a DR track in restricted waters, use the correct tactical data for your ship.)

Computing Turning Bearing and Turning Range

The piloting officer must know at what position the rudder must be put over, so that when allowance is

Table 12-1.—Sample Advance and Transfer Table

Standard Tactical Diameter at 15 Knots Requiring Standard Rudder		
Angle of turn (degrees)	Advance (yards)	Transfer (yards)
15	185	40
30	275	85
45	345	115
60	390	190
75	445	270
90	500	375
105	450	445
120	405	520
135	360	590
150	315	655
165	265	725
180	205	800

made for advance and transfer the ship will steady on the new heading at the desired point. This procedure involves using a predetermined bearing to a known object (turning bearing) and a predetermined range to a prominent point of land to indicate where the rudder should be put over. The navigator uses the turning bearing, since the bridge personnel use bearings to take visual fixes. CIC uses the range to take a radar fix. Figure 12-20 shows how turning bearing and range are determined. In the figure, a ship is steaming at 15 knots on course 180° and must round a bend in the channel to a new course of 255°. Your job is to find the turning bearing to the lighthouse and the turning range to the point of land labeled D, where the rudder should be put over to have the ship on course 255° and on the desired track after it rounds the bend.

First, draw a line parallel to the ship's present course (180°) on the side toward which the turn is to be made at a perpendicular distance equal to the transfer for a 75° turn. (Table 12-1 shows the transfer for a 75° turn at 15 knots to be 270 yards.) The intersection of this line with the new course (255°) is the point (labeled C) where the turn will be completed. From this point, measure back along the line a distance equal

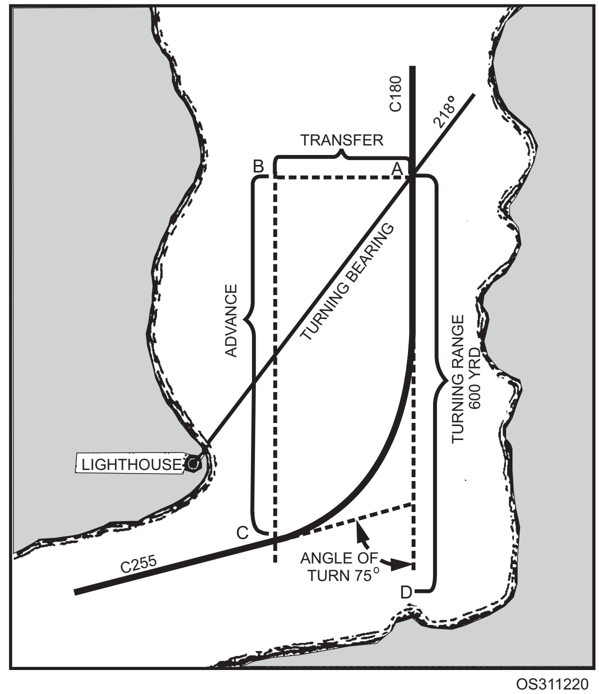


Figure 12-20.—Turning bearing and turning range.

to the advance for a 75° turn. (From the table, this distance is 445 yards.) Label this point (point B in the illustration). From point B draw a line perpendicular to the original course line. The intersection of this perpendicular line and the course line (labeled point A) is where the rudder must be put over. The true bearing of the lighthouse from point A is the turning bearing, 218°, and the turning range to point D is 600 yards (a round figure determined for simplicity's sake). Thus the ship should remain on course 180° until the lighthouse bears 218°, at which point the navigator should recommend right standard rudder. CIC should make the same recommendation when point D is 600 yards away. An accurate way of achieving that is for the scope operator to put the range strobe on 600 yards and the bearing cursor toward point D. When the strobe touches point D, CIC should recommend that the ship begin its. The turn should be completed, with the ship heading 255° at point C. If the ship is not on track as it approaches point A, a line constructed parallel to ship's new course (255°) and drawn through point A will provide the turning point. In figure 12-20, the solid line represents the proposed track of the ship.

Determining Position

The most important part of piloting is establishing the position of own ship. Without an accurately plotted own ship position, called a fix, all other piloting actions are meaningless.

Piloting involves using lines of position that are determined in relation to easily identified and charted landmarks. A fix is obtained from the intersection of two or more lines of position. Basically, there are two general types of lines of position: bearing lines and range arcs. See figure 12-21.

A *bearing line of position* is drawn from the landmark in a reciprocal direction because the bearing indicates the direction of the landmark from the observer. If a lighthouse bears 000°, for example, then your ship is located on the 180° bearing line from the lighthouse.

The *tangent* is a special type of bearing line that provides a line of position to the edge of a point of land that is sufficiently abrupt to provide a definite point for measurement. When a bearing is obtained to the right edge of a projection of land, as viewed by the observer, the bearing is a *right tangent*. Similarly, a bearing to the left edge of a projection of land is a *left tangent*.

A *range arc* is a circular line of position. When the distance from an observer to a landmark is known, the observer's position is on a circle having a radius equal to the measured distance, with the landmark as the center. The entire circle need not be drawn, because in practice the observer normally knows the position near enough that drawing an arc of the circle suffices.

Normally, the navigator obtains fixes by plotting lines of bearing to landmarks, while CIC obtains fixes by plotting radar range arcs from prominent points. However, any combination of lines of position may be used to determine own ship's position. The following methods are used to obtain radar fixes.

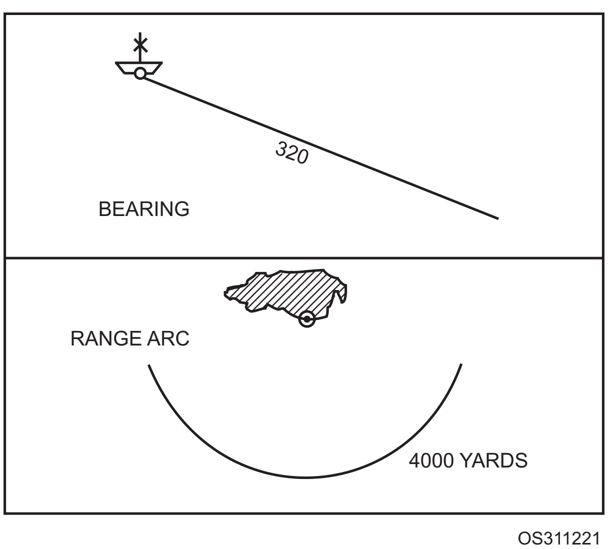


Figure 12-21.—Lines of position.

TWO OR MORE BEARINGS.—Cross bearings by radar are plotted in the same manner that the navigator plots visual bearings. The most rapidly changing bearing (usually closest to the beam) is taken first, followed quickly by the remaining bearings.

Search radar bearings are not normally considered very accurate. However, radar-bearing information can be nearly as accurate as visual bearings when the radar system is properly calibrated and aligned and the operator takes bearings only on well-defined targets. Objects located offshore and away from the landmass, such as small islands, lighthouses, and large rocks, are the best targets for radar bearings. Center bearings taken to isolated targets should be very accurate and can be used to obtain a radar fix. See figure 12-22.

TANGENT BEARINGS.—Tangent bearings to the edges of a large object, such as an island, are perhaps the least accurate of all radar bearings. The beamwidth distortion of the radar accounts for the inaccuracy.

Earlier we discussed the effects of beamwidth on a radar target. We determined that every target is distorted one-half beamwidth either side of its actual shape. With this in mind, whenever a tangent bearing is taken on a radar target, the bearing must be corrected. The rule for correcting tangent bearings to radar targets is simply this: Add one-half beamwidth to the left tangent, and subtract one-half beamwidth from the right tangent.

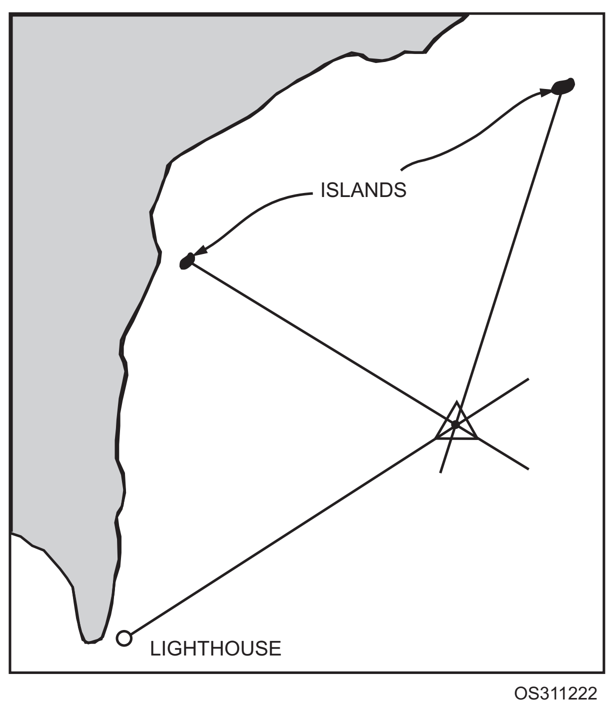


Figure 12-22.—Three-bearing fix.

To further explain the tangent conversion problem, let's consider the situation in figure 12-23. Tangent radar bearings are being taken on an island. The dark form shows the actual shape of the island as it appears on the chart. The light outline around the island shows how it appears on a PPI scope. (The radar has a horizontal beamwidth of 10°.) The bearings obtained from the radarscope are left tangent 342° and right tangent 016°. If you plot these bearings tangent to the island on the chart, they will cross at some point between the island and the actual position of own ship, as shown on the left in figure 12-23. Such a large error cannot be tolerated in radar navigation.

To correct the radar bearings in this situation, we add one-half beamwidth to the left tangent (342° + 5° = 347°) and subtract one-half beamwidth from the right tangent (016° - 5° = 011°). If these corrected bearings are plotted tangent to the island on the chart, they will cross at own ship's position, as shown on the right in figure 12-23.

RANGE AND BEARING TO A SINGLE OBJECT.—A radar fix may be obtained by taking a range and bearing to one object, preferably a small prominent target offshore, as shown in figure 12-24. This method may not be as accurate as one using several lines of position, but it certainly is more rapid.

Normally, a single-object fix is used to supplement other fixes by providing a quick fix of own ship's position. Continuous fixes may be plotted when this method is used. This type of fix can be very helpful during the time between regular fixes, especially in restricted waters or when approaching a turn.

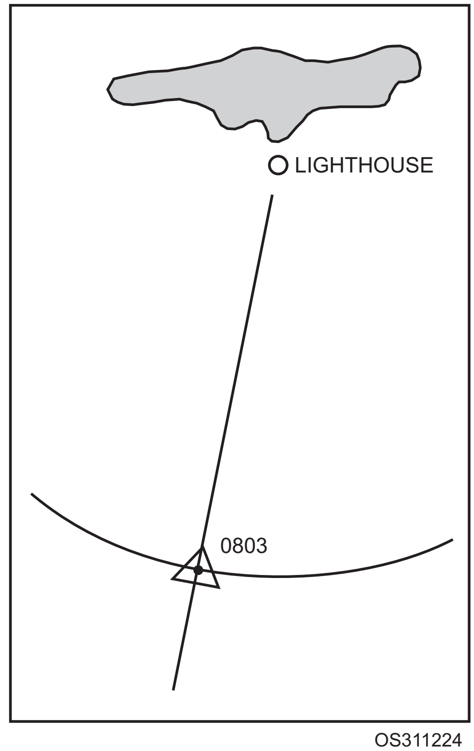


Figure 12-24.—Bearing and range to a single object.

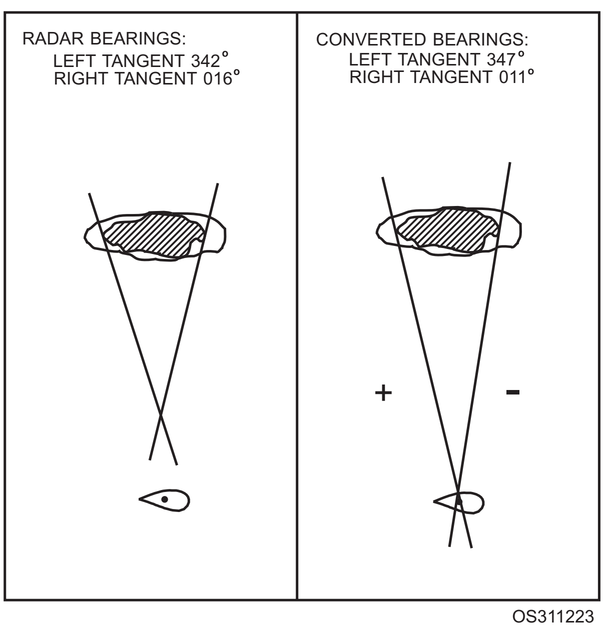


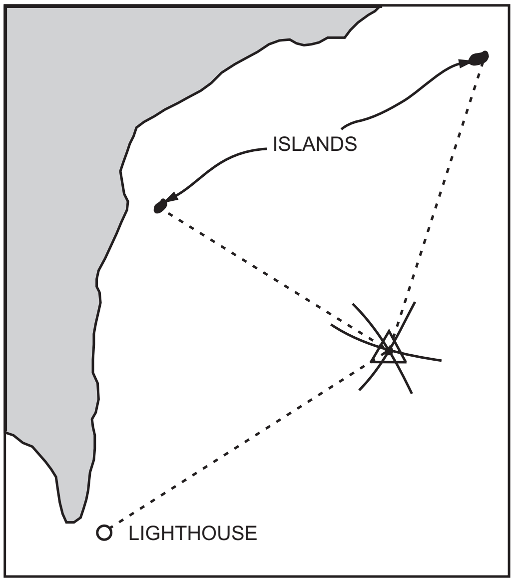
Figure 12-23.—Measured and converted radar tangent bearings plotted on a chart.

TWO OR MORE RANGES.—In most situations, the most accurate position obtained by radar is determined by using two or more (preferably three) ranges. Radars are usually more accurate in range than in bearing. In using the range method, there is no chance for mistakes caused by gyro error or beamwidth distortion.

Figure 12-25 shows a three-range fix taken on three offshore targets. However, range-only fixes may also be obtained by using prominent points along the coastline.

Thus, using two or more ranges is the best method to obtain a fix in CIC. Ranges can be plotted on the chart quickly, and fixes obtained by this method are far more accurate than any of the other methods used in CIC.

You may have noticed that we use a triangle for each fix shown in the illustrations. A triangle indicates that the fix was obtained by electronic means (radar, DF equipment, loran, etc.). Figure 12-26 shows three other symbols used in piloting. The triangle and the half-circle are the symbols most used in CIC.



OS311225

Figure 12-25.—Three-range fix.

Set and Drift

Anyone who has ever rowed a boat across a river or stream in a strong current knows the boat must be pointed in a slightly different direction from the point where it is supposed to land. In other words, a course and speed correction must be applied to offset the effects of wind and current to reach the destination. Ships often experience the same difficulty, requiring the navigator and CIC to respond in the same way.

SYMBOL	DESCRIPTIVE LABEL	MEANING
	FIX	AN ACCURATE POSITION DETERMINED WITHOUT REFERENCE TO ANY PREVIOUS POSITION. ESTABLISHED BY VISUAL OR CELESTIAL OBSERVATIONS.
	FIX	A RELATIVELY ACCURATE POSITION, DETERMINED BY ELECTRONIC MEANS, WITHOUT REFERENCE TO ANY FORMER POSITION.
	DR	DEAD RECKON POSITION. ADVANCED FROM A PREVIOUS KNOWN POSITION OR FIX. COURSE AND SPEED ARE RECKONED WITHOUT ALLOWANCE FOR WIND OR CURRENT.
	EP	ESTIMATED POSITION. IS THE MOST PROBABLE POSITION OF A VESSEL, DETERMINED FROM DATA OF QUESTIONABLE ACCURACY, SUCH AS APPLYING ESTIMATED CURRENT AND WIND CORRECTIONS TO A DR POSITION.

OS311226

Figure 12-26.—Navigation plotting symbols.

Two words are used to describe the effect that external forces, usually wind and current, have on a vessel—*set* and *drift*. *Set* is the direction toward which the forces tend to push a vessel. *Drift* is the velocity of the force, in knots.

The navigator must check through various publications, tide tables, and current tables to predict the amount of set and drift the ship will experience while entering port. Winds, variations in stream discharges produced by heavy rain, and other weather conditions frequently cause actual wind and current conditions to vary from those predicted. It thus becomes necessary for both the navigator and CIC to determine set and drift periodically, especially in restricted waters.

In CIC, you can use the following method to determine set and drift. See figure 12-27.

1. Obtain an accurate fix (shown as time 1405 in the illustration).
2. Dead-reckon (DR) the ship ahead 3 minutes, on course and speed, from the 1405 position. (In figure 12-27 the ship is headed 200° at 12 knots.) When you apply the 3-minute rule, the ship will travel 1200 yards in 3 minutes, or 400 yards per minute. Plot the three DR positions, 400 yards apart, in the direction of 200° from the 1405 fix.
3. At time 1408, or 3 minutes later, obtain another accurate fix.

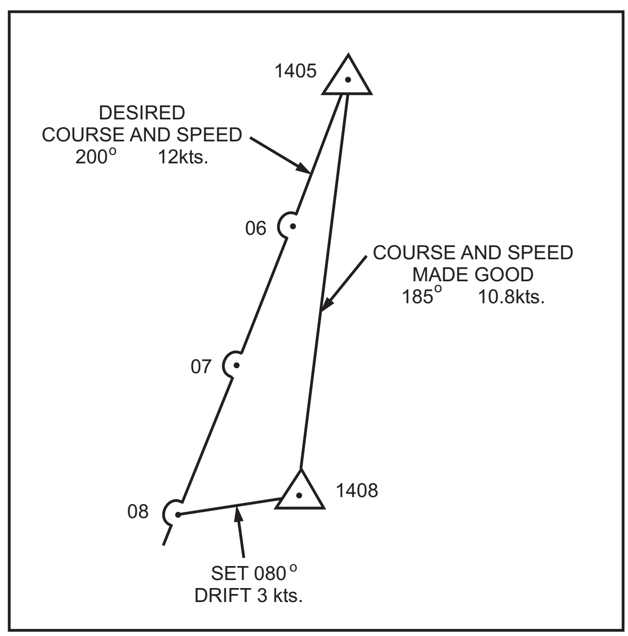


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Figure 12-27.—Determining set and drift.

4. Determine the set. The set is the bearing of the 1408 fix from the 1408 DR position. In figure 12-27, the 1408 fix bears 080° from the 1408 DR position. Therefore, the set is 080°.

5. Determine the drift. Drift is the speed that the ship is being offset from its intended course and is determined by measuring the distance between the fix and the DR position. In figure 12-27 this distance is 300 yards. According to the 3-minute rule, 300 yards translates to a drift of 3 knots.

6. By examining the plot on the chart, we can see that although the ship is heading 200° at 12 knots, it is actually tracking (or making good a course of) 185° at 10.8 knots, because of the 080° set and the 3-knot drift.

Should a situation such as the one in figure 12-27 arise, where own ship is being set off course, your first concern should be to determine the course and speed to get back on track within a specified time. To do so, use the following procedure (See figure 12-28). In this case, we want to be back on track in 3 minutes.

1. After determining set and drift, draw a second set and drift vector from the 1408 fix. (This second vector is the amount of offset your ship will encounter during the next 3 minutes.)

2. Draw a line from the end of the second set and drift vector to the time 11 DR position. This is the course own ship must steer to get back on track. The length of the line indicates the speed that we must use to arrive on track at time 1411. In this case, the course is 219°, and the distance is 1,600 yards. When you apply the 3-minute rule, the speed to use is 16 knots.

An experienced Operations Specialist should be able to recommend a course and speed to return to track in a matter of seconds. Normally, you will use a PMP to determine a course; but if a PMP is not available, you can determine the course, using parallel rulers, by paralleling the course lines to the compass rose printed on the chart. You can use dividers or a compass to measure distance if a PMP ruler is not available.

After you determine the course and speed for returning to the desired track, your next concern should be to determine the course and speed for making good the desired track. Use the following procedure: (See figure 12-29.)

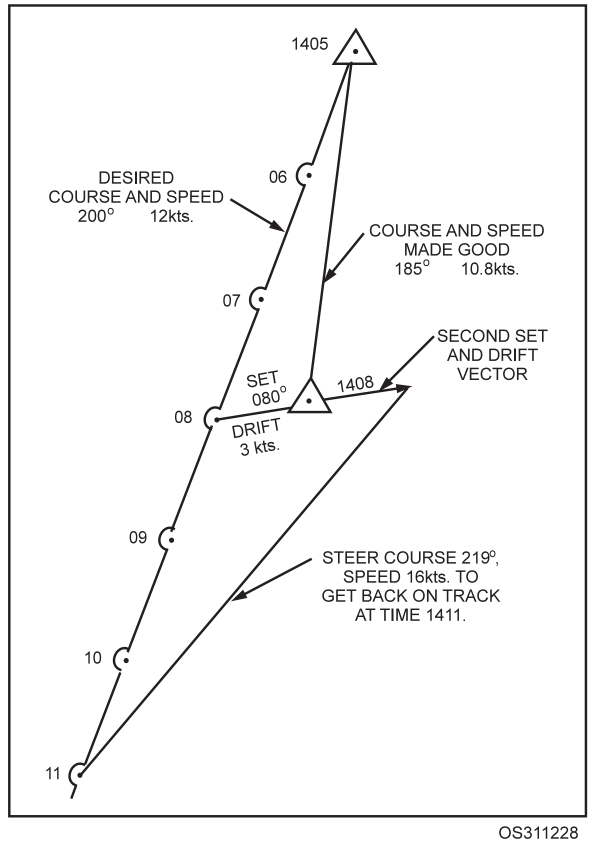

Figure 12-28.—Determining course and speed to return to desired track.

1. From the 1408 fix, draw a line to the time 11 DR position. The direction of this line is the course to use.

2. Determine the speed from the length of the line you just drew. In figure 12-29 the length of this line is 1,380 yards. When you apply the 3-minute rule, the speed to use is 13.8 knots. Your DR track is now 211°, 13.8 knots from the 1408 fix.

Q9. What elements make up a ship's tactical data?

CIC Piloting Team

Getting CIC ready and stationing personnel in their proper position are necessary before CIC can assist in piloting. Unless each person in CIC knows exactly what everyone else in CIC is doing, CIC cannot work as a team.

Figure 12-30 shows a typical CIC station setup. Depending on the type of ship and personnel available, ships could expand or modify the setup as necessary. Consult your ship's CIC Doctrine and Class Combat Systems Doctrine for the exact setup for your ship.

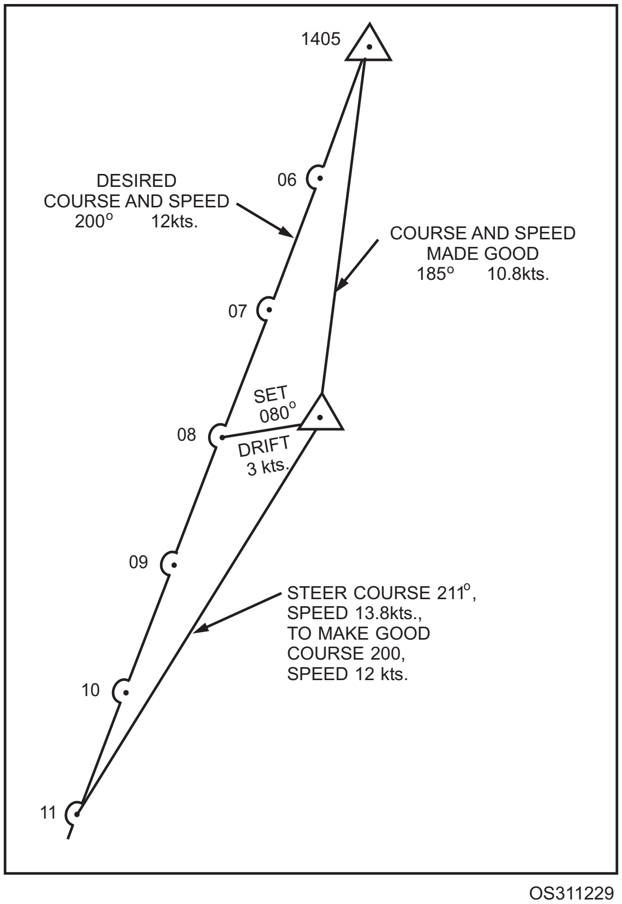

Figure 12-29.—Determining course and speed to use to make good the desired track.

The sound-powered circuits shown are for standard ships. When circuits are not available or are different, they may be modified. If modifications or substitutions are necessary, however, certain groups still should be tied together. For example, groups 1, 2, and 3 should be on the same circuit; 6, 7, and 8 on the same circuit; and P, S, and 10 on the same circuit. For the exact sound-powered phone circuits or IVCS channels for your ship, consult your CIC Doctrine or Class Combat Systems Doctrine.

PILOTING OFFICER.—In communication with the JA talker on the bridge, the piloting officer in our radar piloting setup mans the JA sound-powered phone circuit. The piloting officer keeps the navigational plotter and other concerned members of the team informed of helm and engine orders. The piloting officer also has the following responsibilities:

1. Making piloting recommendations to the conning officer based on the navigation chart, the ship's position, PPI observations, lookout reports, and the policies and preferences of the commanding officer

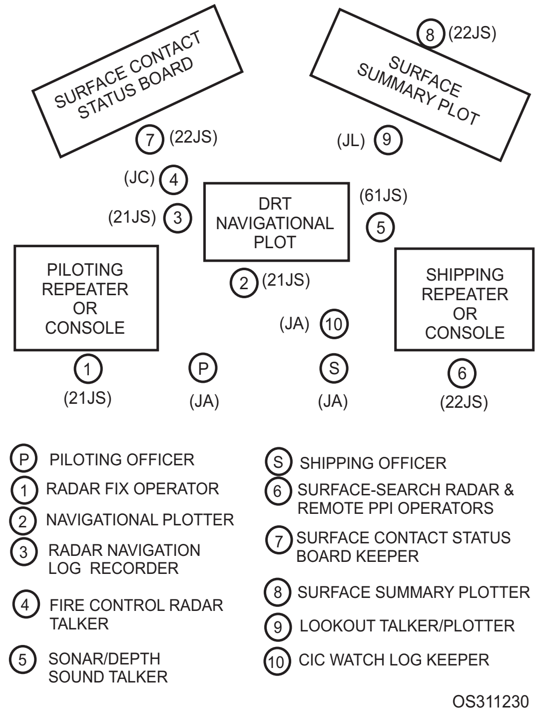

Figure 12-30.—Recommended radar navigation setup (example).

2. Giving adequate and timely warning to the conning officer concerning all dangers to navigation by effectively evaluating the radar navigation track, surface shipping displays, and collected information

NAVIGATIONAL PLOTTER.—The navigational plotter maintains a plot of own ship's position and determines corrections necessary to return own ship to the desired track. Any flat surface can serve as a desk for the navigational chart. A practical surface available in CIC is the top of the dead-reckoning tracer (DRT). Accordingly, the navigational plotter (No. 2 in figure 12-30) works on the south side of the DRT. The plotter must be thoroughly familiar with (1) reading and interpreting chart symbols, (2) correct navigational procedures, (3) computing set and drift, (4) dead reckoning own course and speed made good, and (5) determining compensating and correcting courses and speeds.

The navigational plotter wears the 21JS sound-powered phone and receives information from the navigational PPI operator, the radar navigation log recorder, and the fire control radar talker stationed nearby. It is the navigational plotter who tells the radar navigation log recorder when to obtain fix information. The navigational plotter also directs the fire control radars to lock on targets via the fire control radar talker. The navigational plotter checks in advance with the

CIC officer or the navigator concerning the planned approach track and lays out the proposed track on the chart. Then the plotter determines advance and transfer for expected course changes and indicates turning points and turning bearings or ranges on the chart. The navigational plotter also determines set and drift and informs the navigator and the piloting officer.

In summary, the navigational plotter should do the following:

1. Maintain a complete navigational plot on the chart according to prescribed procedures and techniques. He should obtain fixes, based on at least three lines of position, at intervals no greater than 2 minutes. From each successive fix, the plotter should plot an accurate track 1-minute increments and for periods of at least 2 minutes.

2. Assist the piloting officer in determining from the chart the following data:

   - Relation of the ship's actual position to proposed track position.
   - Location of hazards to navigation (such as shoal water, obstructions, etc.).
   - Location of buoys.
   - Comparisons of depth sounding equipment readings and charted depths.
   - Geographic position of the ship in relation to land references, designated anchorage areas, and the like.
   - Distance and time to turning points and the time for course change.

3. Continuously determine set and drift.

RADAR NAVIGATION LOG RECORDER.—The radar navigation log recorder gives marks and records times, ranges, and bearings of objects used for piloting. He also records recommendations that makes to the conning officer.

During a gunfire support problem, because it is difficult for the navigational plotter to wear phones, the radar navigation log recorder is stationed next to the plotter and records all data in a form that the plotter can see easily. If the plotter wears phones during shore bombardment, he will be cut off from the problem as it rapidly develops upon receipt of a fire mission. When the fire mission is assigned, the navigational plotter hears it over the speaker and also sees the data on the status board. The navigational plotter and the target plotter then quickly locate the target and prepare for the problem. Essentially, the navigation log recorder and the navigational plotter perform as a team during gunfire support, just as in piloting.

NAVIGATIONAL PPI OPERATOR.—Before beginning any navigational problem, the surface radar and PPI operators must study the chart with the navigational plotter and the navigation log recorder. They should then decide the reference points to use. The reference points should be designated using standard alphabetical designations. The surface radar and PPI operators should set all controls at the proper selection for the ranges of primary interest. In general, these operators perform the following functions:

- As requested, they furnish the navigation log recorder and the navigational plotter range and bearing information on designated reference points.
- As applicable, they advise the navigation log recorder and the navigational plotter of the best reference points to use (as they appear on the scope).
- They inform the navigational plotter and the navigation log recorder when ship reaches predetermined turning ranges and bearings.

FIRE CONTROL RADAR TALKER/ RECORDER.—The fire control (FC) radar talker stands next to the navigation log recorder and wears the sound-powered phones connected to the fire control radar operators. The FC talker is responsible for:

- coaching the fire control radar operators onto reference points designated by the navigational plotter or the navigation log recorder, and
- passing to the navigation log recorder and the navigational plotter any navigation information received from the fire control radar stations.

SONAR/DEPTH SOUNDER TALKER/ RECORDER.—The sonar/depth sounder talker/recorder on the 61JS sound-powered phone circuit is stationed next to the DRT when he is communicating with the sonar and depth sounder operators. Aboard ships that have no sonar, another circuit must be used for communicating with the

depth sounder operator. The duties of the sonar/depth sounder talker/recorder are as follows:

- Coaches sonar operators onto designated objects, such as buoys, reefs, shoals, and ships at anchor, assisted by the navigational plotter.
- Records range and bearing information on buoys, shoals, and the like received from sonar operators for use by the navigational plotter in fixing the ship's position.
- Advises the piloting officer or shipping officer of unusual changes such as screw beats heard and the Doppler of contacts.
- Records and reports depth sounder readings to the navigational plotter and piloting officer.
- Requests readings as directed by the piloting officer or according to the doctrine of the ship. (Typically, depth sounder readings should be taken and recorded at least every 30 seconds when the ship is in restricted waters.)

SHIPPING OFFICER.—Usually, the shipping officer supervises the surface picture, while the piloting officer takes care of the piloting detail. In smaller ships, it may be necessary to combine the duties of the piloting and shipping officers. If this happens, a supervisor should oversee and coordinate the surface displays. Whoever is designated the task wears the S/P phones connected to the bridge. The shipping officer must have a thorough knowledge of sound signals for both inland and international waters. The shipping officer is responsible for

- supervising CIC personnel charged with maintaining the surface displays (other than the navigational chart);
- ensuring that the bridge receives timely warning of all shipping of concern to the ship in passage and any amplifying information on this shipping, including an evaluation of fog signals reported by lookouts;
- coordinating the use of the sound-powered circuit with the piloting officer on a time-sharing basis; and
- designating contacts to be tracked, watched, or scrubbed, based on the specific situation and the desires and policies of the commanding officer.

SURFACE-SEARCH RADAR/REMOTE PPI OPERATORS.—Remote PPI operators for the shipping picture actually are standard surface-search operators during normal steaming. They maintain their scopes at a high level of performance and presentation, setting all controls at the proper selections for ranges of primary interest. In the performance of their duties, they also

- provide range and bearing information on contacts designated by the shipping officer or the surface supervisor to enable the surface summary plotter and surface contact status board keeper to maintain the required surface displays;
- report CPAs and bearing drifts of contacts directly from the PPI scope if directed by the shipping officer or the surface supervisor; and
- report new contacts appearing on scopes, according to ship's doctrine.

SURFACE SUMMARY PLOTTER AND SURFACE CONTACT STATUS BOARD KEEPER.—The duties of the surface summary plotter and surface status board keeper, during navigation, are the same as for normal steaming. These personnel are responsible for maintaining complete displays that show designations, times, bearings, ranges, courses, speeds, CPA and times of approach, compositions, and (when known) identifications.

LOOKOUT TALKER/PLOTTER IN CIC.—The lookout talker/plotter in CIC acts as liaison for lookout stations and has the following duties:

- Alerts lookouts to surface contacts approaching the ship from outside visual or audio range
- Passes to the piloting officer reports received on surf, obstructions, buoys, and other objects within visibility range

As a plotter the CIC lookout talker/plotter displays on the surface contact status board any reports received from lookouts as visual identifications.

LOOKOUTS AND TALKERS AT LOOKOUT STATIONS.—Lookout talkers at lookout stations pass to CIC any information on objects within visibility range. Reports include such data as bearing, estimated distance, identification, target angle, and closing or opening range of vessels.

Lookouts must be trained to know what fog signals to expect from a ship underway, a ship underway but with no way on, a ship at anchor, small craft underway, and the like. They should be briefed on diaphones and other anticipated fixed signals. Moreover, they should know how to differentiate between the sound of a ship's whistle and a hand-operated horn.

Reports include bearings and what the lookouts heard: whistles, horns, etc.; how many blasts; duration of the blasts (short or prolonged); whether the blasts are becoming louder or weaker; and whether the other vessel is passing up the starboard side, down the port side, or crossing ahead. Lookouts report when the ship is abeam of buoys. This information aids the radar-piloting officer in establishing the ship's position and acts as a check against electronic information.

CIC WATCH LOG RECORDER.—We will discuss the CIC watch log at length in a later chapter. Because of the volume of traffic during radar piloting, it is advisable to have the JA circuit manned for the purpose of recording the information flow between CIC and the bridge. Recommendations made by CIC should be logged in the CIC watch log as well as in the radar navigation log.

Q10. What member of the navigation team gives timely warning to the conning officer concerning all dangers to navigation?

Radar-Assisted Piloting

The navigator and the CIC officer must agree on when fixes will be taken and must that the time is the same in both the bridge and CIC. By pre-arrangement, the navigator and CIC determine simultaneously. The radar navigation log recorder announces a "Stand by" at 10 seconds before the minute and a "Mark" on the minute. The navigator takes the most rapidly changing bearing (closest to the beam) on the mark, then other bearings. At the same time, the radar operator in CIC gives the most rapidly changing range (ahead or astern) on the mark, then subsequent ranges.

Before a ship leaves or enters port or steams into restricted waters, the navigator studies charts and various other publications, then lays down a safe course for the ship and discusses the proposed track with the commanding officer. As soon as possible, the CIC officer confers with the navigator.

Items of interest to the CIC officer include positions where the navigator desires to change speed, turning reference points, desired time of arrival at the destination, points to use for visual plotting, and the expected current. The CIC officer should have the navigator's proposed track copied on appropriate charts, then study the charts carefully, noting such objects as hazards to navigation. Information indicated on charts includes danger lines, points on the track where the ship should change course or speed or possibly drop anchor (with additional tactical data as required), lines indicating the desirability of changing charts, and other applicable data. Next, the CIC officer should hold a briefing with radar operators to determine the most desirable targets to use in establishing radar fixes and to designate alternate targets. Other problems should be anticipated at this time so that they may be analyzed carefully and solved in advance insofar as possible. Any photographs that are scale models of the terrain should be studied to see what targets the radar will receive. All radar piloting personnel should study the charts carefully. When the special sea and anchor detail is set, the radar piloting team should be well-prepared and ready to work.

COASTAL NAVIGATION

While your ship is within radar range of land, CIC is required to keep a coastal navigation plot on a chart by plotting radar fixes. Make sure that the plot displays the following information:

- The intended track, marked with reference points and all proposed changes of course and speed. (These data are available from the navigation department and from the bridge.)
- Radar fixes every 30 minutes or as required by own ship's doctrine. (Compare these fixes with those the or navigator obtains.)
- The boundaries of the area(s) in which the ship is operating or expects to operate.
- The set and drift of the current.
- The wind direction and velocity.
- The positions of any hazards to navigation.
- The locations of any objects of potential interest.

NAVIGATION AT SEA

Whenever a ship is beyond radar range of land, CIC cannot get navigational information on its own, but must get data from the navigator and maintain an up-to-date plot on the navigational chart. In these

situations, CIC maintains the following information on the chart:

- The ship's position the navigator determined from loran, Omega, satellite, or celestial (stars) data. At these times, the settings of the and NTDS should be compared with the navigator's position and reset if necessary.
- An accurate dead-reckoning plot, showing all course and speed changes and DR positions every 30 minutes (more often when maneuvering).
- The boundaries of the operating area(s) in which the ship is steaming or intends to exercise.
- The location of all hazards to navigation.
- The location, course, speed, and predicted track of all storms.
- The position and estimated time of radar landfall.
- The location of any objects of possible interest, such as ships in distress or position of own or enemy forces.
- PIM (Position and Intended Movement) information.
- When aircraft are being controlled, a plot of the air defense identification zone (ADIZ) line, and a plot of areas in which gun or missile firing is scheduled to take place.
- Radiological fallout reports.

Whether the ship is near land or in the open ocean, Operations Specialists can use navigational plots to aid in the following actions:

- Scope interpretation. — Small isolated islands, for example, often appear to be ships. A check against the chart, from the ship's present position on the chart to the target, will verify whether the target is a ship or land and prevent reporting land as a ship.
- Search and rescue. — Normally, Operations Specialists in CIC are among the first to know when an aircraft is in peril or when a ship is in danger. Thus, by knowing the correct position of the ship and plotting the position of the aircraft or ship in trouble, Operations Specialists can make recommendations immediately to the bridge.
- Conversion plotting. — By using a chart with a grid reference system superimposed, Operations Specialists can change the bearing and range of an object to the reference system or to latitude and longitude.

CHANNEL NAVIGATION IN A FOG

Channel navigation in a fog requires accurate identification of buoys and close coordination between CIC and the bridge.

The first step in CIC is to lay off the track through the channel and make up the buoy check-off list. Most harbors have some channel buoys equipped with radar reflectors. Make special note of these buoys; they will be seen on radar earlier and can be identified more easily than the other buoys.

Through the JL talker, keep the lookouts informed of the bearing of the channel buoys and have them send any visual sightings to CIC. Alert the bridge talker to transmit all visual sightings of buoys by bridge personnel.

Channel navigation in a fog is one of the most nerve-wracking experiences a conning officer encounters. The conning officer is intently peering into a blanket of white fog, with CIC the main source of navigational information. If you maintain a rapid flow of information on course, distance, buoys, and other shipping, the conning officer is assured you are in control of the situation. If the conning officer must ask repeatedly for this information, he has little or no confidence in the ability of CIC.

Just as fog reduces visibility, so do water droplets reduce radar performance. You may not be able to get the same ranges in foggy weather as you can in clear weather. This makes the requirements for peak performance of the radar of even more importance. Make full use of your other important aids—fire control radar, depth finder, and sonar (where installed).

Whenever you obtain an unreliable fix in CIC, plot it as an estimated position, and attempt to obtain a more accurate fix as soon as possible. Swamp and lowland areas in some harbors make it particularly difficult to navigate by radar.

If a ship enters a harbor during reduced visibility, the responsibility for safe piloting is placed in CIC. Under these circumstances, if a situation arises where CIC cannot obtain an accurate radar fix within 2-minutes, CIC must recommend all stop until it can determine an accurate position for own ship.

Figure 12-31 shows a ship's track, as plotted in CIC, entering Charleston Harbor. Note that the estimated positions are immediately followed by a fix. Also note that a turning bearing has been plotted according to the navigator's proposed track. Set and drift were figured at time 0705 and course and speed were adjusted in order to make good the desired track. The time 0710 fix is a single bearing and range fix that was taken quickly as the turning point was approached. In this case, CIC would recommend turning as soon as the 0710 fix was plotted.

The scale of the chart used in figure 12-31 is 1:20,000. A distance scale (not shown in the illustration) is provided at the bottom of the chart for measuring ranges and laying out DR positions.

The time-distance-speed scale, shown in figure 12-32, is a convenient item that you can draw on any chart (to the scale of the chart being used) and use to measure distance traveled at any of the various speeds during 1-, 2-, or 3-minute intervals. For example, if your ship is making 10 knots and you want to plot a 2-minute DR, simply measure up the 2-minute line from the bottom line to the point where the 10-knot line crosses the 2-minute line. That distance indicates how far your ship will travel in 2 minutes at 10 knots.

The time-distance-speed scale is based upon the 3-minute rule and is very accurate. It also takes all of the guesswork out of laying out a DR. It's a good idea to have one of these scales drawn on each of the frequently used harbor charts for a convenient and ready reference.

ANCHORING A SHIP

Often, CIC is given the responsibility for piloting the ship to anchorage. For this phase of piloting, lay off on the charts the complete track (indicate course and speed) of the ship from the time land is first detected until the ship is anchored.

Anchorage charts for the principal harbors of the United States and its possessions are issued to every ship. These anchorage charts are harbor charts with anchorage berths overprinted in colored circles of various diameters. On these charts, series of berths of the same size are laid out in straight lines and are called *lines of anchorage*. Adjacent circles usually are tangent to each other. The center of the circle is the center of the berth. Each berth is designated by a number, a letter, or a combination of both, printed inside the circle.

If you are to anchor in a harbor for which there is no standard anchorage chart, a berth is assigned by giving the bearing and distance of the center of the berth from a known object, together with the diameter of the berth.

When your ship is ordered to anchor in a specific berth, CIC personnel must take the following actions:

- From the center of the berth, draw the letting-go semicircle. Use a radius equal to the horizontal distance between the hawsepipe and the antenna position of the surface-search radar. (The navigator uses the position of bridge wing gyro repeaters.)
- From the center of the berth, lay off the intended track, using the appropriate approach courses and navigational aids for determining the ship's position. Where turns are necessary, locate turning bearings and ranges. If possible, the final approach should be made with the ship heading into the current or the wind. The effects of current and wind and the presence of shipping often preclude a straight course to the anchorage.
- Determine the distance from the hawsepipe of the ship to the radar antenna. Lay this distance off from the center of the berth to locate the letting-go point. From there, draw range semicircles. The usual practice is to draw arcs every 100 yards out to 1,000 yards, then arcs at 1,200, 1,500, and 2,000 yards. Also from the center of the berth, draw bearing lines at 5° and 10° in the direction of your approach and label these lines, using reciprocal bearings. These lines and arcs enable the piloting officer to make recommendations to anchorage without interfering with the navigational fixes being taken.

Figure 12-33 shows an anchorage track. In this track, the ship makes its final approach to the anchorage, using a beacon as a range. Notice the course and speeds, DR positions, turning bearing, final approach course, semicircles indicating yards from the center of the berth, letting-go circle, and anchorage bearing. The ship will turn to the approach course when it reaches the turning bearing and anchor when the stack bears 090°T. Remember, the speed of the ship should be such that it has no headway upon reaching the letting-go point. Slight sternway should be on the ship as soon as the anchor is let go for the anchor to take hold, to lay out the anchor chain properly, and to protect bow-mounted sonar domes.

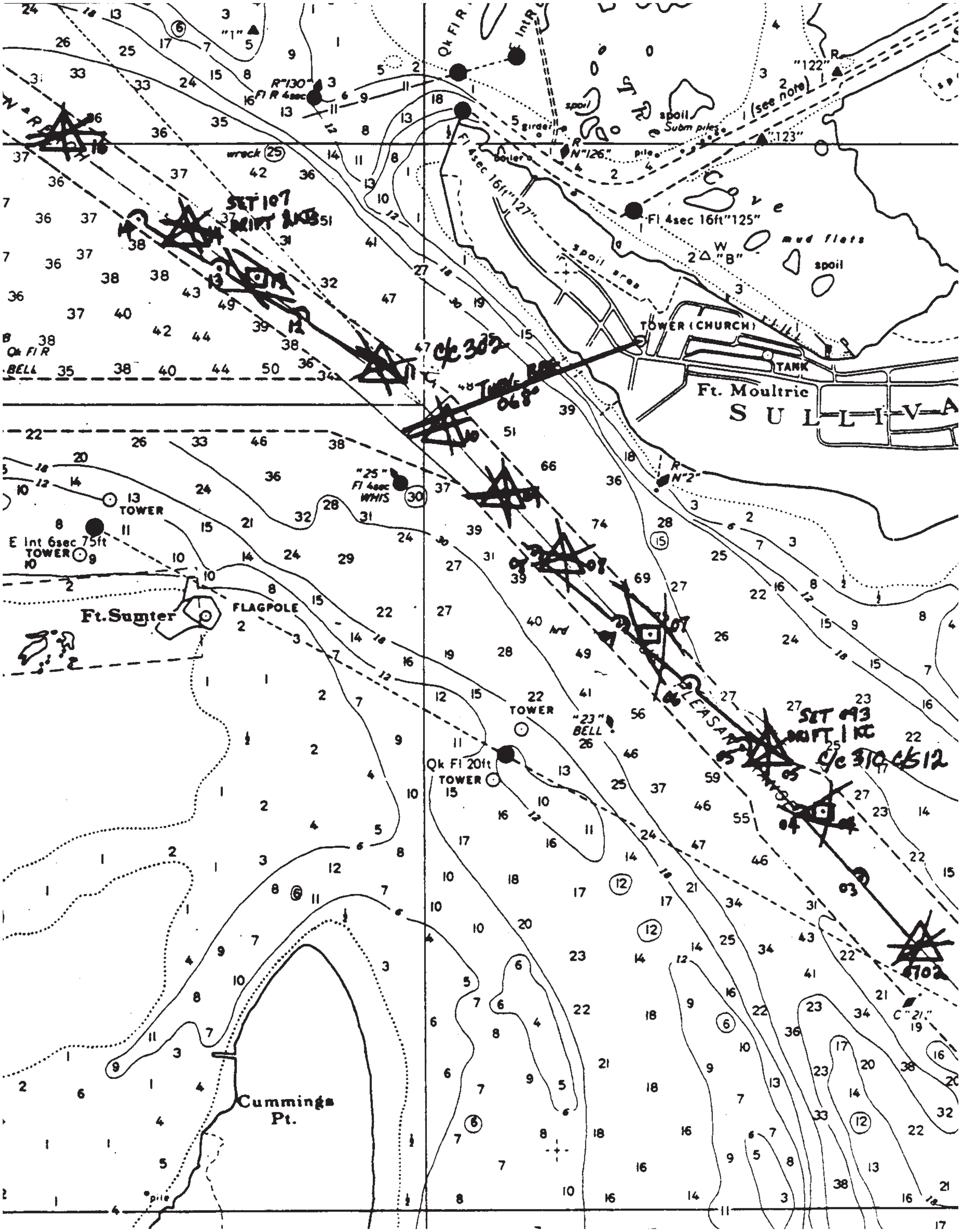

Figure 12-31.—Navigation track as plotted in CIC.

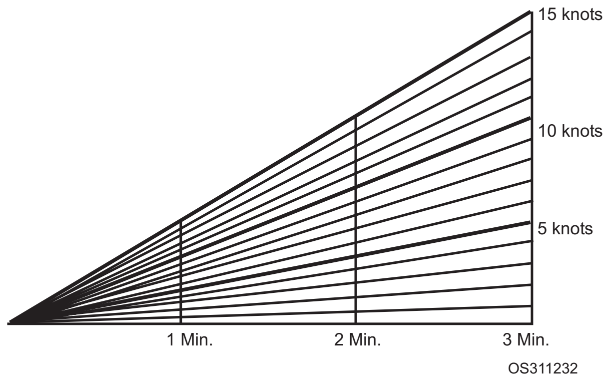

Figure 12-32.—Time-distance-speed scale.

RULES OF THE ROAD

OSs must know and understand the nautical Rules of the Road; the safe navigation of your ship requires the application of various regulations to prevent collisions. There are two sets of rules—International Rules and Inland Rules.

International Rules are specific rules for all vessels sailing on the high seas and in connecting waters navigable by seagoing vessels. The Inland Rules apply to all vessels sailing on the inland waters of the United States and to vessels of the United States on the Canadian waters of the Great Lakes to the extent that there is no conflict with Canadian law.

The International Rules were formalized at the convention on the International Regulations for Preventing Collisions at Sea, 1972. These rules are commonly called the 72 COLREGS.

The Inland Rules discussed in this chapter replace the old Inland Rules, Western River Rules, Great Lakes Rules, their respective pilot rules, and parts of the Motorboat Act of 1940. Many of the old navigation rules were originally enacted in the last century. Occasionally, provisions were added to cope with the increasing complexities of water transportation. Eventually, the navigation rules for the United States inland waterways became such a confusing patchwork of requirements that in the 1960s several unsuccessful

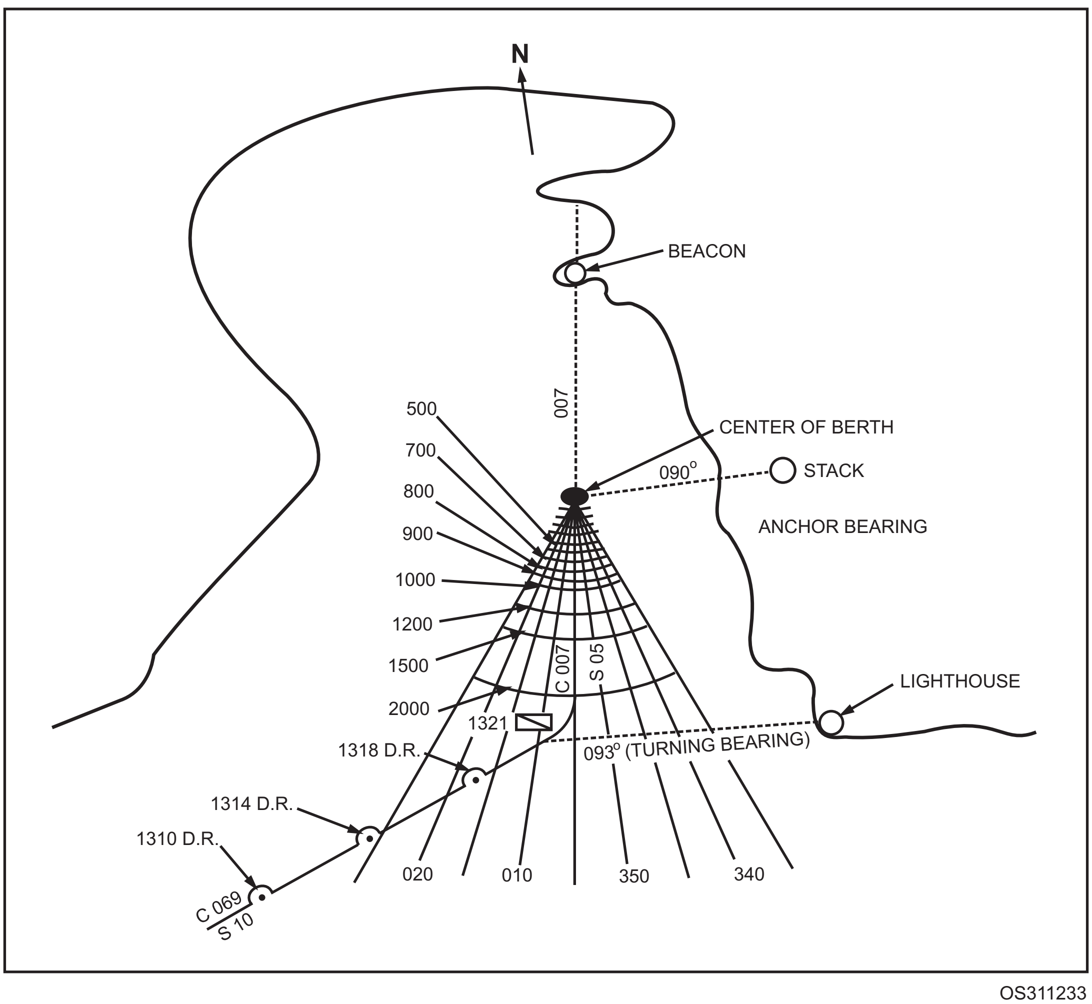

Figure 12-33.—Anchorage track.

attempts were made to revise and simplify them. Following the signing of the 72 COLREGS, a new effort was made to unify and update the various Inland Rules. This effort was also aimed at making the Inland Rules as similar as possible to the 72 COLREGS. The Inland Navigation Rules of 1980, now in effect, was the result.

The International and Inland Rules contain 38 rules that compose the main body of the rules and five annexes, which are the regulations. The International and Inland Rules are divided into the following parts:

Part A — General

Part B — Steering and Sailing Rules

Part C — Lights and Shapes

Part D — Sound and Light Signals

Part E — Exemptions

In this chapter we will present a short discussion of the steering and sailing rules, but the majority of our discussion will be about Part D, which concerns sound signals.

Definitions

Before we get into the requirements for whistle signals, you must first understand the terms we will use.

- The word *vessel* includes every description of , including non-displacement craft and seaplanes, used or capable of being used as a means of transportation on water.
- The term *power-driven vessel* means any vessel propelled by machinery.
- The term *sailing vessel* means any vessel under sail, provided that propelling machinery, if fitted, is not being used.
- The term *vessel engaged in fishing* means any vessel fishing with nets, lines, trawls, or other fishing apparatus that restricts its maneuverability, but does not include a vessel fishing with trolling lines or other fishing apparatus that does not restrict its maneuverability.
- The word *seaplane* includes any aircraft designed to maneuver on the water.
- The term *vessel not under command* means a vessel that, through some exceptional circumstance, is unable to maneuver as required by these rules and is therefore unable to keep out of the way of another vessel.
- The term *vessel restricted in its ability to maneuver* means a vessel that, from the nature of its work, is restricted in its ability to maneuver as required by these rules and is therefore unable to keep out of the way of another vessel.
- The term *vessel constrained by its draft* means a power-driven vessel that, because of its draft in relation to the available depth of water, is severely restricted in its ability to deviate from the course it is following (International Rules only).
- The word *under way* means that a vessel is not at anchor, made fast to the shore, or aground.
- The words *length* and *breadth* of a vessel mean its length overall and its greatest beam or width.
- Vessels are deemed to be *in sight of one another* only when one can be seen from the other.
- The term *restricted visibility* means any condition in which visibility is restricted by fog, mist, falling snow, heavy rainstorms, sandstorms, or any other similar causes.
- The term *inland waters* means the navigable waters of the United States shoreward of the navigational demarcation lines dividing the high seas from harbors, rivers, and other such bodies of waters of the United States, and the waters of the Great Lakes on the United States side of the International Boundary.
- *Demarcation Lines* are the lines delineating waters upon which mariners must comply with the 72 COLREGS and waters upon which mariners must comply with the Inland Navigation Rules. (The boundaries for the demarcation lines are listed in the back of the Coast Guard publication *Navigation Rules*.)
- The word *whistle* means any sound-signaling appliance capable of producing the prescribed blast and which complies with the specifications in Annex III of the International and Inland Rules. (When your ship was built and the whistle was installed, all of the specifications listed in Annex III were considered.)
- The term *short blast* means a blast of about 1 second's duration.

- The term *prolonged blast* means a blast of from 4 to 6 seconds' duration.

Steering and Sailing Rules

You must understand the steering and sailing rules and be able to apply them to various traffic situations. Although all rules of the road are important, the steering and sailing rules are the most essential to know to avoid collision.

Your vessel may be at risk of colliding with an approaching vessel if the approaching vessel does not change its course. However, when you are approaching a very large vessel or when you are in close quarters, a bearing change alone does not necessarily mean that a collision cannot happen. Figures 12-34, 12-35, and 12-36 illustrate the three situations in which the danger of collision might exist: head-on, crossing, and overtaking. The illustrations and the following summary will help you learn the rules and appropriate actions:

1. When two ships meet head-on or nearly so (fig. 12-34), each ship must change course to starboard and pass port-to-port. In international waters, a whistle signal is sounded only when a course change is actually made. If the meeting ships are already far enough off each other to pass clear on their present courses, no signal is sounded.
2. When two power-driven vessels are crossing so as to involve risk of collision (fig. 12-35), the vessel having the other to starboard must keep out of the way and avoid, if circumstances permit, crossing ahead of the other vessel.

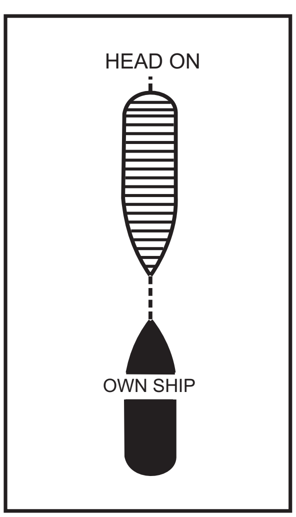

Figure 12-34.—Meeting (head-on) situation.

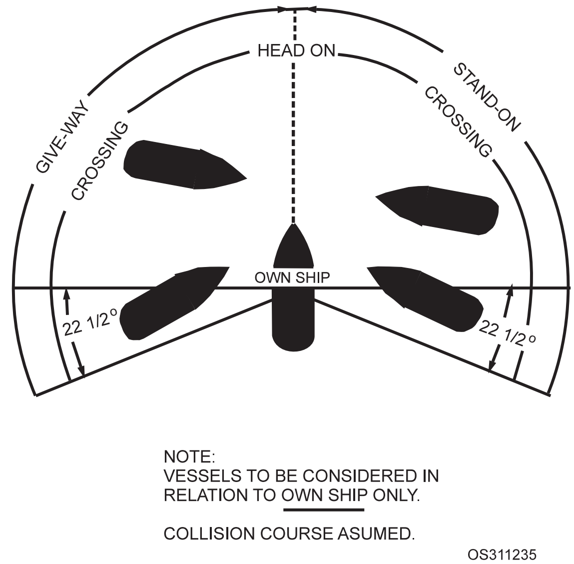

Figure 12-35.—Crossing situation.

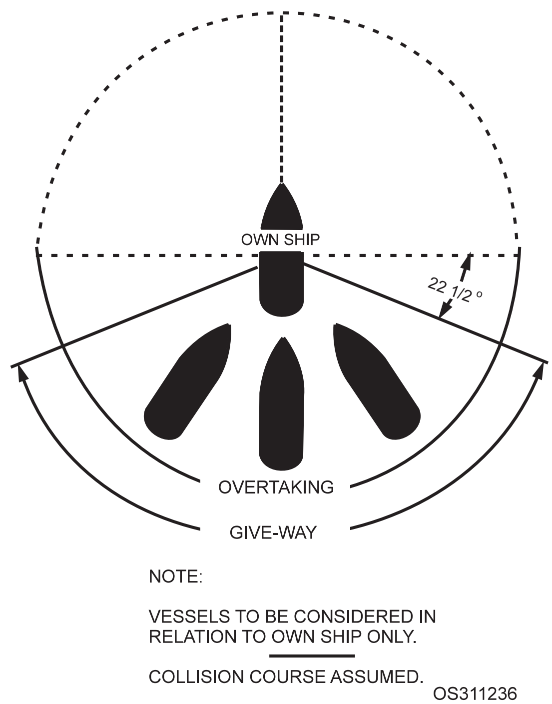

Figure 12-36.—Overtaking situation.

3. A sailing vessel has right-of-way over power-driven vessels except when the sailing vessel is overtaking, and when the power-driven vessel is engaged in fishing, is not under command, or is restricted in its ability to maneuver.
4. Any vessel overtaking another must keep clear of the overtaken vessel. An overtaking vessel is one that is approaching another vessel from any

direction more than 22.5° abaft its beam (fig. 12-36). When in doubt, assume you are overtaking and act accordingly.

Equipment for Sound Signals

A vessel of 12 meters or more in length must be provided with a whistle and a bell. Vessels that are 100 meters or more in length must also have a gong. The tone of the gong cannot be confused with the tone of the bell. Both the bell and the gong must comply with the specifications listed in Annex III. (As with the whistle, these specifications were taken into account when the ship was outfitted.)

A vessel of less than 12 meters in length is not required to carry the sound signaling equipment mentioned above, but must carry some efficient means of sound signaling.

Maneuvering and Warning Signals

Since there are major differences between the international and the inland maneuvering and warning signals, we will presented them separately, and will note the differences on the inland version.

INTERNATIONAL RULES

When vessels are in sight of one another, a power-driven vessel underway maneuvering as authorized or required by these Rules, must indicate its maneuver with one of the following whistle signals:

- One short blast: "I am altering my course to starboard";
- Two short blasts: "I am altering my course to port";
- Three short blasts: "I am operating astern propulsion."

Any vessel may supplement these whistle signals with light signals, repeated as appropriate while it carries out the maneuver. These light signals have the following meaning:

- One flash: "I am altering my course to starboard";
- Two flashes: "I am altering my course to port";
- Three flashes: "I am operating astern propulsion."

The duration of each flash should be about 1 second; the interval between flashes must be about 1 second; and the interval between successive signals must not be less than 10 seconds. The light used for this signal must be an all-round white light, visible at a minimum range of 5 miles, and must comply with the provisions of Annex I to the International Rules.

When two vessels are within sight of one another in a narrow channel or fairway, the vessel intending to overtake the other must indicate its intention with one of the following whistle signals:

- Two prolonged blasts followed by one short blast: "I intend to overtake you on your starboard side";
- Two prolonged blasts followed by two short blasts: "I intend to overtake you on your port side."

The vessel about to be overtaken must indicate agreement with one of the following whistle signals:

- One prolonged blast, one short blast, one prolonged blast, and one short blast, in that order.

When two vessels in sight of one another are approaching each other, they must understand each other's intentions. If one of them fails to understand the intentions or actions of the other or is in doubt whether the other is taking sufficient action to avoid collision, it must immediately indicate its doubt by giving at least five short, rapid blasts on the whistle. It may supplement the whistle signal with a light signal of at least five short, rapid flashes.

A vessel nearing a bend or an area of a channel or fairway where other vessels may be obscured by an intervening obstruction must sound one prolonged blast loud enough to be heard around the bend or obstruction.

If whistles are fitted farther apart than 100 meters on a vessel, only one of the whistles may be used for giving maneuvering and warning signals.

INLAND RULES

When power-driven vessels maneuvering as authorized or required by the Inland Rules are in sight of one another and meeting or crossing at a distance within half a mile of each other, each vessel must indicate its maneuver by giving one of the following whistle signals:

- One short blast: "I intend to leave you on my port side";

- Two short blasts: "I intend to leave you on my starboard side";
- Three short blasts: "I am operating astern propulsion."

NOTES

1. International Rules do not specify a distance for sounding signals.
2. International Rules read "I am," whereas Inland Rules read "I intend to." The one- and two-short-blast signals in the Inland Rules signify an intention of passage with one other vessel.

When one vessel hears a one- or two-blast signal from another vessel, the first vessel must, if it agrees to the maneuver, sound the same whistle signal and take the steps necessary to make a safe passing. If, however, the first vessel doubts the safety of the proposed maneuver, it must sound the danger signal of at least five short, rapid whistle blasts. Both vessels must then take appropriate precautionary actions until they agree that they can make a safe passing.

A vessel may supplement the above whistle signals with the following light signals:

- One flash: "I intend to leave you on my port side";
- Two flashes: "I intend to leave you on my starboard side";
- Three flashes: "I am operating astern propulsion."

Each flash must have a duration of about 1 second, and the light must be one all-round white or yellow light, visible at a minimum range of 2 miles, synchronized with the whistle, and must comply with the provisions of Annex I to the Inland Rules.

NOTES

1. Inland Rules do not specify an interval between flashes or an interval between successive signals.
2. International Rules do not allow a yellow light to be used for light signals.
3. The minimum visible range for light is 2 miles for Inland Rules and 5 miles for International Rules.
4. Inland Rules require that light signals and sound signals be given at the same time (synchronized).

When two power-driven vessels are in sight of one another and one intends to overtake the other, the vessel intending to do the overtaking must indicate its intention with one of the following whistle signals:

- One short blast: "I intend to overtake you on your starboard side";
- Two short blasts: "I intend to overtake you on your port side."

NOTES

1. Inland Rules require signals for overtaking vessels when in sight of one another in a narrow channel or fairway.
2. International Rules require two prolonged blasts preceding the short blast(s) required by the Inland Rules.
3. Overtaking signals are signals of *intention* only and must be answered by the vessel that is being overtaken, in both International and Inland Rules.

If the power-driven vessel about to be overtaken agrees to the maneuver, it must sound a similar sound signal. If it is in doubt about the maneuver, it must sound the danger signal of at least five short, rapid blasts.

NOTE

Inland Rules require the vessel being overtaken to answer with a signal similar to the one sounded by the overtaking vessel, if it agrees. The International Rules require the vessel being overtaken to sound one prolonged, one short, one prolonged, and one short blast, in that order, if it agrees. The Inland Rules for overtaking vessels apply only to power-driven vessels; International Rules apply to all vessels.

When two vessels in sight of one another are approaching and either vessel fails to understand the intentions or actions of the other, or is in doubt whether the other is taking sufficient action to avoid collision, the vessel in doubt must immediately indicate its doubt by giving at least five short, rapid blasts on the whistle. It may supplement this signal with a light signal of at least five short, rapid flashes.

A vessel nearing a bend or an area of a channel or fairway where other vessels may be obscured by an intervening obstruction must sound one prolonged blast. Any vessel within hearing around the bend or behind the intervening obstruction must answer this signal with a prolonged blast.

If whistles are fitted on a vessel at a distance apart of more than 100 meters, only one whistle may be used for giving maneuvering and warning signals.

NOTE

There are no provisions made in the International Rules for the following situations:

1. When a power-driven vessel is leaving a dock or berth, it must sound one prolonged blast.
2. A vessel that reaches agreement with another vessel in a meeting, crossing, or overtaking situation by using the radio-telephone, as prescribed by the Bridge-to-Bridge Radiotelephone Act (85 Stat. 165; 33 U.S.C. 1207), is not obliged to sound the whistle signal prescribed by Inland Rules, but may do so. If the two vessels cannot reach agreement on the radio-telephone, they must exchange whistle signals in a timely manner.

Sound Signals In Restricted Visibility

The sound signals for restricted visibility required by International and Inland Rules are very similar. In this part of the text, we will present only the Inland Rules, but we will note any difference between the International and Inland rules.

In or near an area of restricted visibility, whether by day or night, the following signals apply:

- A power-driven vessel making way through the water must sound one prolonged blast at intervals of not more than 2 minutes.
- A power-driven vessel under way but stopped and making no way through the water must sound two prolonged blasts in succession, with an interval of about 2 seconds between them, at intervals of not more than 2 minutes.
- The following vessels must sound one prolonged blast followed by two short blasts at intervals of not more than 2 minutes: A vessel not under command; a vessel restricted in its ability to maneuver, whether under way or at anchor; a sailing vessel; a vessel engaged in fishing, whether under way or at anchor; and a vessel engaged in towing or pushing another vessel.

NOTES

1. In the Inland Rules, no provisions are made for a vessel constrained by its draft.
2. International Rules address vessels engaged in fishing while at anchor and vessels restricted in their ability to maneuver when carrying out work at anchor separately. The sound signals required for these situations are the same as those for the same situations in the Inland Rules.

A vessel towed, or if more than one vessel is towed, the last vessel of the tow, if manned, must sound one prolonged followed by three short blasts at intervals of not more than 2 minutes. When practical, this signal must be made immediately after the signal made by the towing vessel.

When a pushing vessel and a vessel being pushed ahead are rigidly connected in a composite unit, they are regarded as a power-driven vessel and give the signals prescribed earlier for a power-driven vessel making way through the water or a vessel under way but stopped and making no way through the water.

A vessel at anchor must, at intervals of not more than 1 minute, ring the bell rapidly for about 5 seconds. In a vessel of 100 meters or more in length, the bell must be sounded in the forepart of the vessel, and immediately after the ringing of the bell, the gong must be sounded rapidly for about 5 seconds in the aft part of the vessel. A vessel at anchor may, in addition, sound one short, one prolonged, and one short blast to give warning of its position and of the possibility of collision to an approaching vessel.

A vessel aground must give the bell signal and, if required, the gong signal prescribed above and must, in addition, give three separate and distinct strokes on the bell immediately before and after the rapid ringing of the bell. A vessel aground may, in addition, sound an appropriate whistle signal.

A vessel of less than 12 meters in length is not required to give the above-mentioned signals but, if it does not, the vessel must make some other efficient sound signal at intervals of not more than 2 minutes.

A pilot vessel, when engaged on pilotage duty, may, in addition to the signals prescribed for a power-driven vessel under way making way through the water; under way but stopped and not making way through the water; or at anchor; sound an identify signal consisting of four short blasts.

NOTE

The International Rules do not cover the following situations:

The following vessels are not required to sound signals prescribed for an anchored vessel when anchored in a special anchorage area:

1. Vessels of less than 20 meters in length
2. A barge, canal boat, scow, or other nondescript craft

Responsibility

Where collision is so imminent that it cannot be avoided by the give-way vessel alone, it immediately becomes not only the right but the expressed duty of the stand-on vessel to take whatever action will best help to avert collision. Each vessel must do all in its power to avert the collision no matter which one may have the right-of-way.

The responsibility rule (International and Inland rule 2) makes it impossible for a stand-on vessel to escape responsibility after standing into danger simply because its skipper decided not to haul off when he or she had the right-of-way. Rule 2(b) is as follows:

"In construing and complying with these Rules due regard shall be had to all dangers of navigation and collision and to any special circumstances including the limitations of the vessels involved, which may make a departure from these Rules necessary to avoid immediate danger."

Q11. *The Inland Rules of the Road apply to what vessels in what bodies of water?*

ANSWERS TO CHAPTER QUESTIONS

A1. *Mercator projection.*

A2. *360.*

A3. *60.*

A4. *Cartesian coordinates, the world geographic reference (GEOREF) system, and the universal transverse Mercator grid (UTM).*

A5. *The world geographic reference (GEOREF) system.*

A6. *Part 2.*

A7. *April and October.*

A8. *Notice to Mariners.*

A9. *Acceleration,deceleration, acceleration/deceleration distance, advance, transfer, tactical diameter, final diameter, and standard rudder.*

A10. *The piloting officer.*

A11. *All vessels sailing on the inland waters of the United States and vessels of the United States on the Canadian waters of the Great Lakes to the extent that there is no conflict with Canadian law.*

CHAPTER 13

SEARCH AND RESCUE

LEARNING OBJECTIVES

After you finish this chapter , you should be able to do the following:

1. Discuss the National Search and Rescue Plan.
2. Describe the SAR organization.
3. Identify the various types of SAR incidents and emergency signals.
4. Describe the procedures followed in CIC during a SAR mission.
5. Describe the procedures for a SUBLOOK/SUBMISS/SUBSUNK situation.

INTRODUCTION

"Search and rescue (SAR)" is the use of available personnel and facilities to render aid to persons and property in distress. Since ancient times, sailors have recognized the moral obligation to assist persons in distress. The armed forces have traditionally accepted, to the extent practical, a moral or humanitarian obligation to aid nonmilitary persons and property in distress. However, the acceptance of formal search and rescue procedures as a part of standard military operations is fairly recent. This acceptance has been further implemented for the United States by the National SAR Plan.

THE NATIONAL SEARCH AND RESCUE PLAN

The National SAR Plan provides for the control and coordination of all available assets for all types of search and rescue operations. The plan established the three SAR regions shown in figure 13-1 (inland, maritime, and overseas) and designated a SAR coordinator for each region. By government interagency agreement, the regional coordinator, through a cooperative network of participants, coordinates all SAR operations in its area. The SAR coordinators and their assigned area are:

- Inland Region — U.S. Air Force
- Maritime Region — U.S. Coast Guard
- Overseas Region — Overseas unified commanders.

Regional SAR coordinators are responsible for organizing existing agencies and their facilities into a basic network for rendering assistance both to military and nonmilitary persons and to property in distress.

SEARCH AND RESCUE ORGANIZATION

The basic objectives of the SAR organization are to ensure that the following actions are taken:

1. Prompt dissemination to interested commands of information about a distress incident requiring SAR assistance.
2. Prompt dispatch of appropriate and adequate rescue facilities.
3. Thorough support of SAR operations until a rescue has been made or until it is apparent that further efforts are not warranted.

SAR FACILITIES

The term "SAR facilities" encompasses the personnel, equipment, and accommodations necessary to perform SAR operations. The term essentially pertains to boats, vessels, aircraft, land vehicles and the personnel to man them.

Since there is a continuing requirement for military SAR in support of military operations, each armed service is responsible for providing SAR facilities in support of its own operations. Therefore, each armed service must consider its own SAR needs first. However, all DOD facilities are available for use

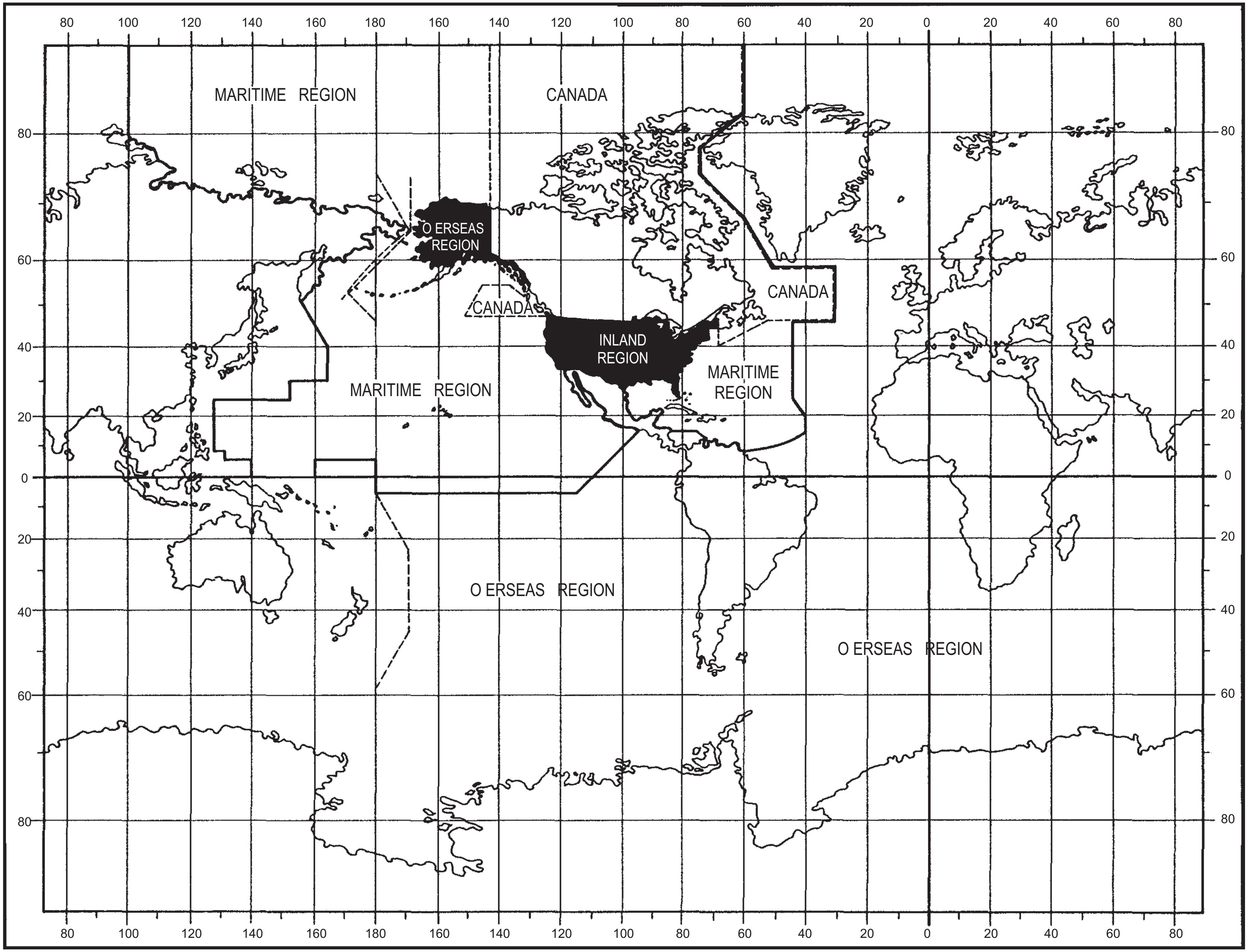

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Figure 13-1.—Inland, Maritime, and Overseas SAR Regions.

to meet civil needs on a not-to-interfere (with military operations) basis.

U.S. Navy Facilities

SAR facilities are inherent to all naval operations. U.S. Navy forces, both ashore and afloat, are well adapted for SAR due to the mobility and extensive communication networks common to their operations. Along with the available SAR facilities of aircraft, ships, and submarines, the Navy maintains a worldwide long-range DF (direction-finding) network that can provide bearing and fix information for SAR missions. In numbers, equipment, and widespread geographical location, Navy facilities constitute a major SAR potential for all areas included in the National SAR Plan.

U.S. Coast Guard Facilities

The Coast Guard is a branch of the Armed Forces of the United States. In time of peace, it operates as a service within the Department of Transportation. In time of war or when the President directs, it operates as a specialized service within the Naval Establishment.

The Coast Guard has specific statutory authority and responsibility for developing, establishing, maintaining, and operating rescue facilities on and over the high seas and waters subject to the jurisdiction of the United States. In carrying out its search and rescue function, the Coast Guard may, by mutual consent, use the facilities and personnel of other agencies. It may also use its own facilities and personnel to assist the other agencies. Coast Guard SAR facilities include cutters, boats, fixed-wing and rotary-wing aircraft, numerous shore stations, and rescue coordination centers. Coast Guard operations also are supported by an extensive communications network, specialized landline circuits, and numerous communications centers.

SAR REGIONS

As we mentioned earlier, the National SAR Plan organizes SAR responsibilities into regions as the basic structure for SAR operations. The boundaries of the SAR areas were established for broad planning purposes. When necessary, SAR forces move into other SAR areas of responsibility without restriction or change in operational direction.

Inland Region

The Commander, Aerospace Rescue and Recovery Service, U.S. Air Force, is the Inland Region SAR coordinator. He is responsible for establishing and implementing SAR procedures in his region.

Maritime Region

The Commandant, U.S. Coast Guard, coordinates the Maritime Region. The maritime region is divided into two main areas of responsibility—the Atlantic Maritime Region and the Pacific Maritime Region. These 2 regions are divided into 11 subregions and finally into 12 sectors.

Overseas Region

The Secretary of Defense, with recommendations from the Joint Chiefs of Staff, designates certain officers as unified commanders of specified areas where U.S. forces are operating. The two major areas are the Atlantic Overseas Region and the Pacific Overseas Region. Wherever such commands are established, the unified commander, as regional SAR coordinator, has responsibility for coordinating and, as appropriate, controlling military and civil SAR within the Inland or Maritime Regions.

SAR COORDINATOR

A SAR coordinator (SC) is an official responsible for coordinating and, as appropriate, controlling SAR operations in a SAR region, subregion, or sector. A SAR region is the highest level of coordination. A SAR subregion is the geographical area formed by dividing a SAR region into smaller areas of responsibility. A SAR subregion may be broken down into sectors.

Each SC establishes a *rescue coordination center (RCC)* to coordinate and control all participating search and rescue units and facilities within his area of responsibility.

SAR MISSION COORDINATOR

The SAR mission coordinator (SMC) is the official designated by the SAR coordinator for coordinating and controlling a specific SAR mission. There must be an SMC for each SAR mission, and he must keep the SC informed of all pertinent details of the SAR mission in progress.

The SMC has the following general duties:

1. Alert appropriate SAR facilities and organizations that may be of assistance.
2. Dispatch the initial SAR force, if required.
3. Provide for the search crew's briefing and debriefing, and designate the on-scene commander (OSC).
4. Maintain a continuous plot, usually in the RCC, of DF bearings, areas searched, and fixes.

ON-SCENE COMMANDER

The on-scene commander (OSC) controls SAR operations and communications at the scene of a distress mission when the SAR mission coordinator cannot exercise control of the mission.

The commander of the first unit on the scene assumes OSC duties, pending designation by the appropriate SMC. Once a commander assumes OSC duties, he will usually remain the OSC, even when a unit arrives whose commanding officer is senior to him.

We have provided the general OSC check-off list below to familiarize you with the specific duties of an OSC, since your ship could become the on-scene commander in a SAR incident.

On-Scene Commander's Check-off List (General)

1. Establish and maintain effective communications with the SMC and the RCC.
2. Assume operational control and coordinate the efforts of all SAR facilities assigned to the established search area.
3. Establish communications with all SAR facilities within the area. Receive position reports and other reports. Be responsible for communications between and performance of SAR facilities. Make regular position reports and other reports as warranted to the SAR mission coordinator, via established communication links.
4. Report weather, wind, and sea conditions to the SAR mission coordinator immediately upon arrival at the scene. Report at least every 4 hours thereafter unless otherwise directed.
5. Determine the endurance of the SAR facilities.
6. Provide details of the mission to participating SAR facilities.
7. Using the SMC action plans, assign specific search subareas and specify search patterns to be used. In short, search the area in the most efficient manner possible, taking into account the limitations and capabilities of the SAR facilities as well as the sea, wind, weather, visibility, and other conditions on the scene.
8. Notify the SMC when action plans must be modified due to on-scene conditions.
9. Control and coordinate all SAR operations within the assigned area, keeping the SAR mission coordinator fully advised of conditions and developments.
10. Advise the SAR mission coordinator as various SAR units depart the search area.
11. If your ship must depart the assigned search area, turn over OSC duties to that SAR unit with the best capabilities to perform them and notify the SAR mission coordinator accordingly.
12. Submit numbered situation reports (SITREPS) to the SAR mission coordinator.
13. Request additional assistance from SMC if needed.
14. Conduct air traffic control services in the area, if capabilities permit, to provide separation of search aircraft (advisory control only).

SEARCH AND RESCUE UNIT

A search and rescue unit (SRU) is a SAR facility that actually conducts the search, rescue, or similar operation during any of the SAR stages. SRUs may be surface vessels, submarines, ground parties, aircraft or ground vehicles. While on the scene, SRUs carry out the SMC's SAR action plans under the direction of the OSC. Units are responsible for efficiently and thoroughly searching the assigned area(s) and reporting all facts of search progress to the OSC. General duties of the SRU are as follows:

1. Establish communications with the OSC approximately 15 minutes before it arrives at the SAR scene. Maintain communications with the OSC until it is released and departs the area.
2. Upon reporting for duty, inform the OSC of all capabilities or limitations of the unit that will affect operations. This includes breakdowns in

navigation, communications, radar, and sonar equipment; and anything else that may affect the ship's speed on station or its endurance capability.

3. Notify the OSC of the sighting and pickup of survivors, informing him of their position, identity, physical condition, and immediate needs for health and welfare.

4. Pick up all lifeboats, life rings, debris and unusual objects, if possible, and report the findings to the OSC, regardless of any seemingly insignificance.

5. Monitor SAR radio frequencies and report all possible survivor transmissions; determine the DF/EW bearings, if they are obtainable.

6. Search continually with passive sonar for possible bearing cuts on noises from distress craft and emergency devices.

7. Be prepared to direct other SRUs to the scene of rescue.

8. Continually monitor IFF for emergency codes or squawks, particularly if the subject of search is an aircraft.

To be adequately prepared for a SAR incident, you should be familiar with the *National Search and Rescue Manual* (NWP 3-50.1). It is likely that CIC will "run the show" for your unit in the search phase, guided primarily by your knowledge and experience and that of your fellow Operations Specialists.

Q1. Who controls SAR operations and communications at the scene of a distress mission?

THE SAR INCIDENT

Speed is of the essence during a SAR incident. The probability of finding survivors and their chances of survival diminish with each minute that passes after an incident occurs. All units must therefore take prompt and positive action so that no life will be lost or jeopardized through wasted or misdirected effort. In each incident, you must presume that there are survivors who need medical aid or other assistance. You must also assume that there is no able-bodied, logical-thinking survivor at the scene. The shock following an accident is often so great that even strong-minded individuals tend to think and act illogically.

TYPE OF INCIDENT

Different criteria have been established to determine if a type of craft (aircraft, surface vessel, or submarine) needs SAR assistance. The following paragraphs identify the criteria that require SAR action for each type of craft.

Aircraft Incident

A SAR incident involving an aircraft is considered imminent or actual when any of the following conditions exist:

1. The position of the aircraft raises doubt about its safety.

2. Reports indicate that the operating efficiency of the aircraft is so impaired that a forced landing may be necessary.

3. The aircraft is overdue. An aircraft on an IFR flight plan is considered overdue when neither communications nor radar contact can be established with it and 30 minutes have passed after its estimated time over a specified or compulsory reporting point or at a clearance limit. An aircraft on a VFR flight plan is considered overdue when communications cannot be established with it and it fails to arrive 30 minutes (15 minutes if it is a jet) after its estimated time of arrival. An aircraft not on a flight plan is considered overdue if a reliable source reports it 1 hour overdue at its destination.

4. The aircraft is reported to have made a forced landing or is about to do so.

5. The crew is reported to have abandoned the aircraft or is about to do so.

6. Any unit receives an emergency IFF/SIF signal.

7. A unit has received a request for assistance, or distress is apparent.

8. A unit has a radar contact flying a left-handed or right-handed triangular pattern.

Surface Vessel Incident

A SAR incident involving a surface vessel is considered imminent or actual when any of the following conditions exist:

1. It is apparent that the vessel is in distress, or it has sent a request for assistance.

2. The vessel is considered overdue at its destination, or its position report is overdue.
3. The vessel has transmitted a distress signal.
4. The vessel is reported to be sinking or to have sunk.
5. The crew of the vessel is reported to have abandoned ship or is about to do so.
6. The vessel is reported to have its operating capability so impaired that it may sink or that its crew may have to abandon it.

Submarine Incident

Submarine incidents differ from other SAR incidents in that they are complex operations involving special equipment and procedures. When a submarine incident occurs, the SAR coordinator will take whatever action is possible with forces available to him and will coordinate activities as in any other SAR incident until special forces can be organized to conduct the operations. We will discuss submarine incident procedures (SUBLOOK, SUBMISS, and SUBSUNK) later in this chapter.

EMERGENCY SIGNALS

Various types of signals may be used to indicate an emergency or distress situation. In a SAR incident, Operations Specialists are concerned with signals that may be heard on CIC communication circuits or seen on CIC detection equipment. Knowledge of such signals is essential since they may be seen or heard only once, and then briefly.

Urgency Signal

The urgency signal consists of three transmissions of the word PAN preceding the transmission of the urgent message. The urgency signal indicates that the calling station has a message to transmit concerning the safety of a ship, aircraft, or other vehicle, or of some person on board or within sight.

Distress Signals

Distress signals are used to indicate that a craft or person is threatened by grave and imminent danger. One distress signal consists of the spoken word MAYDAY.

Another distress signal is the Emergency Position Indicating Radio Beacon (EPIRB) or Emergency Locator Transmitter (ELT). You may hear the EPIRB or ELT signal, commonly referred to as *the beeper*, on the VHF/UHF distress frequencies 121.5 and 243.0 MHz. The tone you hear may be the sweeping down of the modulated carrier frequency, a steady tone, a warbling tone, or a "beep beep" tone.

Radar

Two methods that an aircraft can use to show distress on radar are dropping chaff and flying a triangular pattern.

CHAFF.—Chaff dropped from an aircraft at a rate of four drops at 2-minute intervals, followed by four 360° left-hand turns, is recognized as a distress signal. Survivors may also fire chaff from a flare gun.

TRIANGULAR PATTERNS.—If you are operating a radar scope or console and observe an aircraft making a 120° turn every 1 or 2 minutes to form a triangular pattern, inform your supervisor immediately. This is a commonly used distress signal for aircraft, indicating communication difficulty. Left-hand turns indicate complete radio failure, while right-hand turns indicate that the aircraft can only receive (it cannot answer) transmissions.

Q2. What word spoken three times on a radio circuit is the urgency signal?

Q3. What frequencies do the EPRIB and ELT transmit on?

CIC PROCEDURES

Any time a SAR incident occurs, it is possible that your ship may be the SRU. This task may be assigned by higher authority if it involves duty at a position far from your operating area. It will normally be assigned by the OTC of your task organization if it involves aiding a craft or person within the immediate area. A unit does not necessarily need to be tasked to become an SRU. Any commander of an organization, including a commanding officer of a vessel or aircraft, is expected to engage in SAR operations on his own initiative should the circumstances warrant.

The function of a CIC in SAR may be to assist the RCC or, when directed, to assume primary control as OSC. It is likely that CIC will control and coordinate the ship's efforts in its SAR responsibilities under the direction of the commanding officer. CIC receives and evaluates all reports of distress, organizes and controls

the rescue and return of survivors, and keeps all interested commands informed of SAR progress.

Shipboard procedures, particularly CIC duties and responsibilities, differ from ship to ship. Therefore, we will discuss only general internal requirements in this section. As an Operations Specialist, you should be review the SAR information contained in your ship's CIC/Combat Systems Doctrine for specific onboard procedures.

GENERAL CIC RESPONSIBILITIES

Just as other SAR coordinating participants need action checklists, so does your CIC. The following check-off list will aid any CIC in accomplishing the preliminary duties designated to an SRU by the *National Search and Rescue Manual*.

Preliminary CIC SAR Check-off List

1. Contact radio central as quickly as possible to set up SAR communication frequencies for CIC.
2. As soon as communications are established, contact the OSC for specific requirements and amplifying information or instructions.
3. Brief CIC personnel and lookouts on all aspects of the SAR mission and each watchstander's specific search priorities.
4. Review emergency and distress signals with CIC personnel and lookouts.
5. Keep abreast of weather conditions, both en route and at the scene, so that CIC can notify search and rescue personnel, in advance, of any environmental states that may require them to make special preparations.
6. Plot the datum area, including the established datum error, on the appropriate chart and show the sea current at the scene. Indicate all areas already searched and by whom.
7. Plot the information from item 6 on the DRT/DDRT and nautical chart, using the appropriate scale as the ship approaches or arrives at the scene.
8. Fifteen to 30 minutes before your ETA at the scene, prepare a message for transmission to the OSC by voice or broadcast. The message should contain the following information:
    a. ETA on scene.
    b. Current IFF/SIF transponder setting.
    c. Whether the SAR vessel's aerobeacon is tuned and identified.
    d. Limitations of communications, navigation, or other operational capability.
    e. Speed of advance.
    f. On-scene endurance.
    g. Intended departure point and time, if not via the OSC position.
9. Prepare a search plan of your area (if one is assigned) for the commanding officer's approval.

DETERMINING THE SEARCH AREA

Planning a search involves (1) estimating the most probable position of a distress incident or its survivors, (2) determining a search area large enough to ensure that the survivors are somewhere within the area, (3) choosing the equipment to be used in the search, and (4) selecting the search patterns to be used in covering the area. Detailed procedures for calculating distress craft position, search area characteristics, and search patterns are contained in the *National SAR Manual*. The following overview is provided as an introduction to SAR planning.

Estimating Probable Position

Regardless of the perfection with which search patterns are carried out, all is for naught unless the survivors are within the area searched. Thus, the most important factor is the initial estimation of probable position.

There are several ways to determine the most probable position of a distress incident:

- by a navigational fix,
- by a radar or DF net,
- by the position reported by a witness or the distressed craft at the time of the incident, or
- by dead reckoning from the last known or reported position.

The extent of the search area is based on the most probable position of the survivors, taking into account such factors as errors in position, survivors' drift,

navigation errors of search craft, and meteorological conditions.

Surface Drift Forces

Survivors adrift are at the mercy of the winds and currents. The longer survivors are adrift, the farther they will be from their original position. The probable position of survivors, with a drift correction, is called the *datum*. Datum calculations are made using the *drift interval* — the interval in time between the time of the incident and *the time of the rescue unit arriving on the scene (datum time).* The datum must be corrected constantly throughout the search as factors affecting it change. Also, keep in mind that the datum referred to in SAR is the *best estimated position* of the distress vessel and _not_ the last known position, as in ASW.

Drift is the movement of a floating object due to various currents. To be more specific, drift in the open sea depends on—

1. Sea current (set and drift applied over the entire drift interval)
2. Wind current (current generated by local winds)
3. Leeway (movement of an object through the water due to the local wind's pushing against the exposed surfaces of the object, less the countering force of drag caused by water pushing against the underwater surfaces of the object. This phenomenon does nor occur with submerged objects or a man in the water, as there is not sufficient exposed surface area.)

You can compute the sea current by obtaining the average sea current from nautical charts and publications and multiplying that figure by the drift interval.

To determine wind current, refer to chapter 5 of the *National SAR Manual* or chapter 6 of ATP-10.

Calculate leeway by averaging local surface winds to obtain average surface winds (ASW) and then use that data in one of three uncertainty situations (discussed later in this chapter) to determine datum. Leeway direction is based on the reciprocal direction of the ASW, and varies depending on which uncertainty situation is being used. You can estimate leeway speed by using table 13-1 (considered reasonably accurate up to 40 knots of wind speed, *U*). The *National SAR Manual* and ATP-10 provide details.

Drift is plotted as shown in figure 13-2. Point E is the datum point.

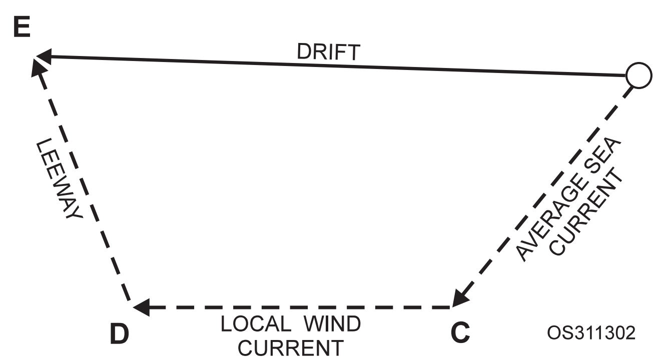

Figure 13-2.—Plotting drift.

Table 13-1.— Leeway Table

TYPE OF CRAFT	LEEWAY SPEED
Light displacement cabin cruisers, outboards, rubber rafts, etc. (without drogue)	0.07U + 0.04kt*
Large cabin cruisers	0.05U
Light displacement cabin cruisers, outboards, rubber rafts, etc. (with drogue)	0.05U - 0.12kt*
Medium displacement sail-boats, fishing vessels such as trawlers, trollers, tuna boats, etc	0.04U
Heavy displacement deep draft sailing vessels	0.03U
Surfboards	0.02U

***Note: Do not use for values of U below 5 knots**

Q4. What are the four most used ways to determine the probable position of a distressed vessel?

Minimax Plotting

In cases where leeway is a factor (i.e. the search object is not submerged and is not a man in the water) a minimax solution is used. Due to the specific uncertainties in data, you will need to plot both a minimum drift (D_{min}) and a maximum drift (D_{max}) estimate. There are three uncertainty situations:

1. Time uncertainty — uncertainty about the time the distress craft has been adrift.
2. Drift rate uncertainty — there are two different types of distress craft and there is uncertainty about the rate at which the distress craft are drifting.
3. Directional uncertainty—uncertainty about the direction in which the distress craft is drifting.

Time uncertainty occurs when you have doubt concerning when the craft actually went adrift. For example, when a fishing boat is overdue you might not be able to determine whether the boat went adrift early in the day or later. Using the earlier estimated start of drift time, calculate a maximum drift distance. Then use the later estimated start of drift time to calculate a minimum drift distance.

Drift rate uncertainty occurs when you are searching for *2 different types* of objects with different rates of speed of drift. For example, a raft with a drogue and a raft without a drogue will drift at different rates. Also, a destroyer and one of its life rafts will drift at different rates because of their different physical characteristics. By using the drift rate of the slower drifting object, you can determine the minimum drift distance; and by using the drift rate of the faster drifting object, you can determine the maximum drift distance.

Use directional uncertainty when you know drift start time and there is a single drift rate. Directional uncertainty takes into account the type of distressed craft and the estimated angle its drift will diverge from the wind axis due to wing angles, drag and so forth. Divergence values vary from 45º for large-keel vessels to 60º for small-keel vessels. The *National SAR Manual* contains a table of values. The divergence value is plotted as a vector on either side of the wind axis. Drift distance, determined by using the leeway speed and drift interval, is plotted along each of those vectors. The minimum drift distance is the plotted position closest to the incident position.

No matter which uncertainty situation you use, determine and label the position midway between the D_{min} and D_{max} positions *datum minimax ($D_{minimax}$)*. This is the best estimate position of the distress craft and is the point around which search efforts will be centered.

Drift is plotted as shown in figure 13-2. Sea current, wind current, and leeway are added vectorially to the incident position to determine $D_{minimax}$ position (figure 13-3).

Q5. What are the three types of current that affect the drift of a floating object?

Sinking Drift

Sometimes, you may have to estimate the position (underwater datum) of a vessel on the ocean, sea, lake, or river bottom. When a vessel sinks, it is subject to various underwater currents. We assume that after an object sinks it will continue to descend until it comes to rest on the bottom.

Determining an underwater datum is easier if you understand underwater currents and boundary layers, and if you take advantage of information contained in appropriate nautical charts and publications and various environmental messages. You also need to know how to apply the rate of descent. Since we know that a submarine not under power sinks at a rate of 2 feet per second, we can assume (lacking any other available information or statistics) that this is also the rate for other objects.

To compute sinking drift, we will use an example of a submarine not under power that has sunk in 480 feet of water. At a sinking rate of 2 feet-per-second, the submarine took 4 minutes or .07 hour to reach the bottom. Available information indicates an underwater current of 160°T at 5 knots. Unlike wind direction, water currents are reported in the direction that they are moving. Therefore, the sinking submarine would have moved in a 160°T direction from its last surface position.

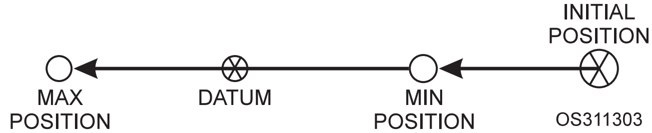

Figure 13-3.—Minimax plotting.

To compute the distance the submarine traveled underwater, convert the underwater current speed to either yards per hour (2,000 yards = 1 mile) or feet per hour (6,000 feet = 1 mile). Five knots is equal to 10,000 yards per hour. During the 4-minute sinking time, the submarine should have traveled 700 yards (0.07 hour x 10,000 yards/hour) in a 160°T direction from its last surface position.

SEARCH AREA COVERAGE

As time passes in a SAR situation, the area of probability must be enlarged because drift error increases as time passes. In addition, the area itself must be shifted to account for drift. (See figure 13-4.)

Probability of Detection

Careful planning and organization are essential in setting up a SAR operation. Despite these efforts, however, a successful recovery depends completely on the accuracy of the SRUs at the scene. Assuming that watchstanders and lookouts are searching properly and diligently, the ability for initial detection is greatest when the target is closest to the observer. As the survivors' range from the observer increases, the probability of detection decreases.

Track Spacing

Any organized search of a recovery area is based on having the search vessel(s) follow specified, usually parallel tracks through the area in order to cover the area properly (See figure 13-5). The tracks may be swept simultaneously by several search units or successively by a single search unit.

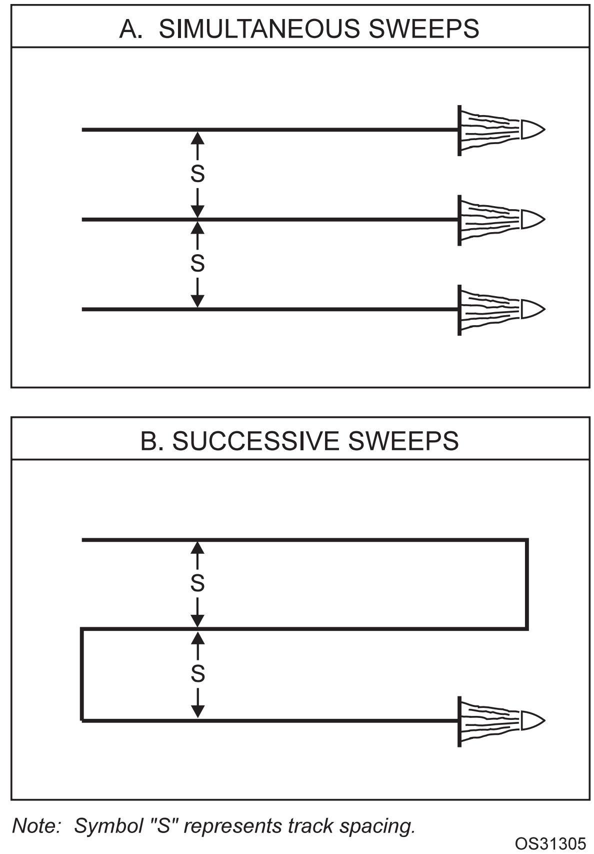

Figure 13-5.—Track spacing.

The distance between adjacent search tracks is called *track spacing*. The probability of detection increases as the track spacing is decreased; however, decreasing track spacing also reduces the amount of area that the SRUs can cover in a given amount of time. Track spacing can be increased for searching larger areas, but this reduces the probability of detection and, in extremes, may even produce gaps in search coverage between SRUs.

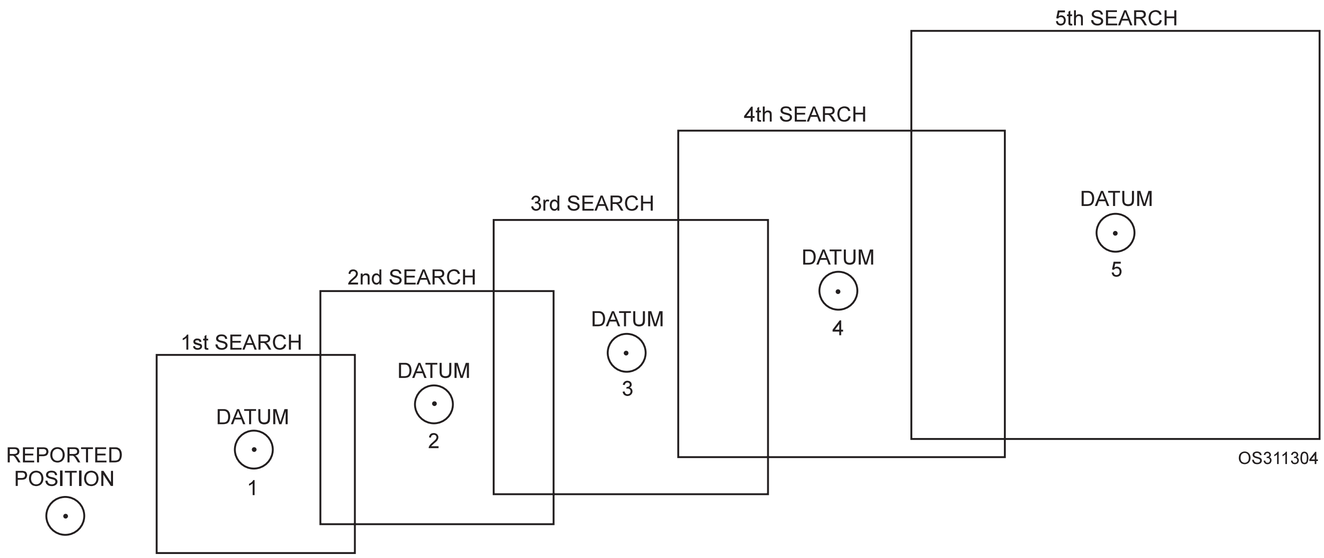

Figure 13-4.—Search areas based on moving datum point.

So how do you know what track spacing is the optimum for a particular situation? Optimum track spacing is whatever spacing provides the best expectation of target detection in the available time and that is consistent with the economical use of the available SRUs. Ideally, optimum track spacing will eliminate both gaps and excessive overlap between units and will still cover the largest area possible with the best detection probability. Track spacing, like sweep width, is measured in yards for underwater search and in nautical miles for all other searches. Specific procedures for calculating track spacing based on search, environmental, and search unit characteristics are in the National SAR manual.

Time

Time is an essential factor in determining the most efficient way to deploy available search units in a particular area. Once the required time is established, the SMC or OSC can determine whether or not to request additional SAR facilities.

CONDUCTING THE SEARCH

The preparations a vessel assigned as a search unit takes will depend upon its electronic detection and communication capabilities. If aircraft are to be used in the search, another consideration is how well the vessel's aircraft control personnel have been trained.

Normally a naval vessel or Coast Guard cutter will use CIC for laying out the various plots and status boards, coordinating on-scene communications, monitoring search progress, issuing advisories to aircraft, carrying out coordinated search patterns, etc. Generally, only ships that operate with established CICs are ever assigned to control radar-coordinated searches.

Aircraft

When your ship is tasked to control an aircraft in radar-coordinated searches, CIC should make immediate preparations before the aircraft reports on station. CIC must first compute the various headings, speeds, and times required for both the ship and the aircraft to execute each search leg in timed coordination. Next, CIC must lay out a "surface" or "true" plot (figure 13-6) on the DRT/DDRT to depict the geographical area to be covered during the search and the planned search tracks of both the vessel and the aircraft. The plot should also include the tracks of other surface vessels of interest.

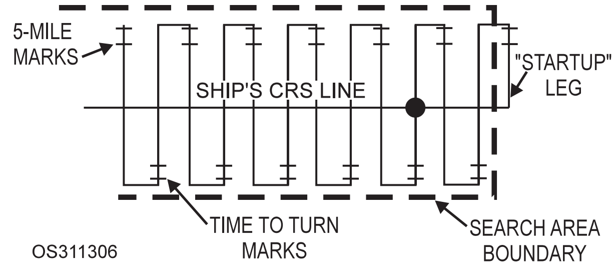

Figure 13-6.—Surface plot/true plot.

If your ship is the OSC and, at the same time, conducts a coordinated search pattern, your DRT plot must also show the subareas assigned to other SRUs, with the first two or three search legs plotted in each subarea. Each leg should show the *commence search point (CSP)*, search leg orientation, and the direction of creep. Vectors to the CSP for each arriving aircraft SRU should also be shown.

After the DRT/DDRT plot is completed, CIC should make up an air plot or relative plot showing the relative motion pattern that will be continually executed during the search. This plot should also show magnetic headings, true headings, wind direction and speed, sea swell direction, and recommended ditch headings for the search aircraft. The plotter should maintain the tracks of all aircraft of interest on this plot during the search.

Finally, CIC should prepare the various advisories for search aircraft operating in the coordinated search pattern.

Surface Craft

With known values for the ship's course, search leg length, and track spacing, the search pattern can be layed out on the DRT/DDRT. When the aircraft and ship are ready to begin searching, the ship will take a position one-half track spacing inside the search area and vector the aircraft to the ship and then onto its initial "startup" search leg. As the aircraft passes over the ship and begins the first search leg, the DRT/DDRT bug should be started, with ship's speed cranked in. Both the aircraft's and the ship's positions should be marked each minute on an appropriate chart or standard tracing paper placed on the surface plot. The surface plot provides the only permanent record of the search since the air plot, on which the controller bases most of his flight advisories, is scrubbed after each leg is completed. Therefore, all sightings must always be plotted on the surface plot.

In addition to the time and position of all sightings, the following information should be placed on the surface plot:

1. Ship's course.
2. Search pattern. (Draw in the search legs at the proper track spacing):
   a. Each leg marked 5 miles from its end.
   b. Each leg marked at the time to turn onto the cross leg.
3. Coordinates of the datum, if known.
4. Area designation (A-1, A-2, etc.) in each designated area.
5. Coordinates of the center point.
6. Major axis.
7. Search legs:
   a. Direction of creep (arrow).
   b. First two or three legs drawn in (need not be to scale).
8. Search altitude.
9. Type and call sign of each search unit.
10. Vector from the OSC position to the commence search point (CSP).
11. IFF/Mode 3A squawk and air-to-air TACAN channel assignments.

Outside the coordinated search area, but adjacent to it, the following information should be plotted:

1. Aircraft's radio call.
2. Aircraft's assigned search altitude.
3. Assigned track spacing.
4. Type of pattern.

It is essential that CIC supervisory personnel establish procedures, documented in the CIC doctrine, to provide for the effective and continuous flow of information between the surface plotter and other vital stations, such as air controller, air plotter, radar and EW search operators, lookouts, and the bridge. This ensures a complete and accurate surface plot, and subsequent relay of necessary data from one station to another.

Sightings

As we previously stated, all sightings should be reported to CIC for inclusion on the surface plot and the air plot. Generally, sightings may be anything observed that is unusual or out of place in relation to the surrounding environment. Such sightings should be reported even if they seem irrelevant to the observer. The following is a list of some of the items that should be reported:

1. Persons in the water.
2. Liferafts and life jackets.
3. Oil slicks.
4. Debris and trash of any kind.
5. Water discoloration and colored dye marker.
6. Clothing.
7. Buoys.
8. Flares.
9. Smoke.
10. Any audible screams, whistles, etc.
11. Concentrations of marine life.
12. Lights or mirror-like flashes.
13. Erratic or unusual maneuvers by vessels or aircraft.

SUBMARINE DISASTER INCIDENT-EVENT SUB LOOK/SUBMISS/SUB SUNK

A form of SAR that operates within, but is slightly different from standard SAR procedures is identified as EVENT SUBLOOK/SUBMISS/SUBSUNK. This form is unique to the Navy, as it involves the search for a missing submarine.

SUBLOOK is the general uncertainty phase; SUBMISS is the initial search stage; and SUBSUNK is the full-scale search. These three stages make up the Navy's submarine disaster search and rescue operations, the primary mission of which is to render prompt assistance to the submarine through rapid search, location, and rescue.

Responsibility for executing SUBLOOK/ SUBMISS/SUBSUNK procedures is tasked to the commander exercising operational control of submarine units, i.e., the submarine operating

authority (SUBOPAUTH). His operation orders contain detailed instructions on policies and procedures for SUBMISS/SUBSUNK for submarines under his control.

ORGANIZATION

The basic organization of personnel for submarine rescue is the submarine SAR mission coordinator, the on-scene commander, the commander rescue force, the search force, and the rescue force. We describe their duties briefly below, but you can find additional details in the *USN Addendum to NWP 3-50.1).*

Submarine SAR Mission Coordinator

The submarine SAR mission coordinator is the SUBOPAUTH of the submarine involved in the disaster incident. He assumes this duty under the overall direction of the SAR coordinator of the area in which the incident occurred.

On-Scene Commander

Usually, the commander of the first SRU to arrive at the disaster scene or the datum point is the OSC. His duties and qualifications, and the circumstances of his relief, are the same as for any other SAR incident.

Search Force

The search force consists of submarines, aircraft, and surface units that will conduct the search for the submarine in distress.

Rescue Force

The rescue force consists of a rescue unit, a service unit, and a base unit that supports the submarine SMC. The rescue unit is used to rescue survivors, using a rescue chamber and other special equipment.

EXECUTION

Should a submarine fail to report on time, the SUBOPAUTH will initiate EVENT SUBLOOK. To do this, he initiates a message to the submarine by radio, alerts other Navy ships in the vicinity, and possibly initiates an air search.

EVENT SUBMISS

When actions taken during EVENT SUBLOOK yield no results, the SUBOPAUTH executes EVENT SUBMISS and advises the appropriate SAR coordinator of his action. He also alerts other commanders who may be of assistance during the SAR mission.

Execution of EVENT SUBMISS indicates the following conclusions:

1. The safety of the submarine is in doubt.
2. The arrival or other accountability report/message is overdue, and the steps required in EVENT SUBLOOK have been completed.

Execution of EVENT SUBLOOK initiates the following procedures:

1. Ordering all suitable ships and submarines available to head for the submarine's position or best estimated position at best speed and to commence search as directed by the OSC.
2. Requesting that at least one aircraft from any command begin an air search.

EVENT SUBSUNK

If any of the following conditions are met, EVENT SUBSUNK must be started:

1. A submarine fails to surface promptly, following a known accident.
2. There is reason to suspect that a submarine has suffered a casualty and requires assistance. Indications of a submarine disaster that call for the immediate execution of EVENT SUBSUNK include:
   a. Sighting a submarine messenger buoy.
   b. Sighting green dye marker.
   c. Sighting a distress pyrotechnic (red) fired from a submarine.
   d. Sighting survivors, an oil slick, debris, or large air bubbles.
   e. Receiving a distress communication by sonar, emergency radio buoy, or submarine emergency communication transmitter buoy.
3. The requirements of EVENTS and SUBMISS have been completed.

The initiation of EVENT SUBSUNK requires the following actions to be taken:

1. Augmenting the search force.

2. Requesting a full-scale air search.
3. Establishing and issuing a datum for the search, giving the depth in fathoms and indicating how the datum will be marked.
4. Establishing the search areas.

Search

Factors and conditions considered in planning the search and determining search plans are generally the same as for any other SAR mission. There are several additional considerations that must be weighed when the target is a distressed submarine.

A datum must be established as accurately as the available information will permit. The method of determining the datum must be passed to all units (for example, loran "C," loran "A," and celestial) and the actual readings provided.

The datum will be marked by the most practical means (a buoy or anchored ship, if the depth of the water permits) to provide a visual reference point.

The entire established probability area should be searched as soon as possible by all possible means.

Of particular significance to CIC is a transmission from the submarine's emergency radio buoy or the emergency communication transmitter buoy. The emergency radio buoy, if released, should transmit "SOS SUB SUNK SOS" on 121.5 MHz or 243.0 MHz. The submarine emergency communication transmitter (CLARINET MERLIN) buoy, if released, should transmit a coded message at 13 to 15 words per minute. The message should consist of the CW characters "HM," repeated 10 times, "USS OSC," and three word groups of three characters each. The transmission is about 3 minutes long on each of four frequencies: 6721.5 kHz, 9033.5 kHz, 11264.5 kHz, and 15055.5 kHz. Since the buoy is large and untethered, the geographical location must be fixed and its drift determined before it is recovered.

SAR AND THE OPERATIONS SPECIALIST

The Navy carries out SAR responsibilities as detailed in step-by-step procedures contained in appropriate OPORDERS. Procedures vary slightly from OPORDER to OPORDER. Therefore, you must know the specific procedures that apply to your particular area of operations.

Since time is such a critical factor in SAR operations, all involved commands are obligated to use every service or facility available. Suppose, for example, the survivors of a downed Navy aircraft are out of UHF range, but they can be heard on a HF distress frequency. How does your ship acquire a DF bearing? Most likely, your ship is unable to do so, but the RCC can obtain the bearing and possibly a fix on any HF transmission, and you may be the only one who hears it. You will not have time to break out the books and research the subject. CIC is usually the SAR center aboard ship; and you must have complete knowledgeable of the subject. To be able to perform your SAR duties properly when the time comes, keep yourself up to date!

Q6. *What are the three types of submarine disaster situations?*

Q7. *Who is responsible for executing a submarine disaster event?*

ANSWER TO CHAPTER QUESTIONS

A1. *The on-scene commander (OSC).*

A2. *PAN.*

A3. *121.5 and 243.0 MHz.*

A4. *Navigational fix, radar or DF net, position reported by a witness or the distressed craft at the time of the incident, dead reckoning from the last known or reported position.*

A5. *Sea current, wind current, leeway.*

A6. *EVENT SUBLOOK/ SUBMISS/SUBSUNK.*

A7. *The commander exercising operational control of submarine units, i.e., the submarine operating authority (SUBOPAUTH).*

APPENDIX I

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INDEX

D

E

F

T

U